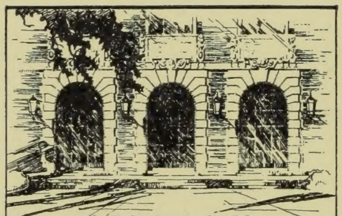

Columbia College in the City of New York

COURSE

IN THE 24

SCHOOL OF MINES

IN

MINING ENGINEERING

LEADING TO THE DEGREE OF

ENGINEER OF MINES

1895–96

NOTE

COLUMBIA COLLEGE offers in addition to the course detailed in this pamphlet:

In the SCHOOL OF ARTS:

A four-years' course leading to the degree of . . . . A.B.

In the SCHOOL OF LAW:

A three-years' course leading to the degree of . . . . LL.B.

In the SCHOOL OF MEDICINE (College of Physicians and Surgeons):

A four-years' course leading to the degree of . . . . M.D.

In the SCHOOL OF MINES:

A four-years' course	in	Civil Engineering	leading to	the degree of	C.E.
"	"	Electrical Engineering	"	"	E.E.
"	"	Metallurgy	"	"	Met.E.
"	"	Geology and Palæontology	"	"	B.S.
"	"	Analytical and Applied Chemistry	"	"	B.S.
"	"	Architecture	"	"	B.S.

A two-years' post-graduate course in Sanitary Engineering leading to the degree of . . . . S.E.

Also many courses in the various university faculties, especially the Faculties of Political Science, Philosophy, and Pure Science, leading to the university degrees of A.M. and Ph.D. A combination of courses under the Faculties of Law and Political Science leads to the degree of LL.M.

The first-year courses of the School of Law, the College of Physicians and Surgeons, and the School of Mines, are open, as electives, to Seniors in the School of Arts. Consequently, such Seniors as may desire to do so can prepare themselves for advanced standing in these schools by electing these first-year courses and counting them for the degree of A.B.

Information as to any of the above courses may be had by addressing the Secretary of the President, Columbia College.

All the schools and departments of Columbia College are at Madison Avenue and 49th Street, with the exception of the Department of Biology and the Medical School, which are at Tenth Avenue and 59th Street.

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1898-1903, 1904/05-1906/07, 1909/10
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GENERAL STATEMENT

The four-years' course leading to the degree of Engineer of Mines is intended primarily to train men to undertake the development of mineral properties, and to operate and manage mines and metallurgical works. The course necessarily is a broad one, including a wide range of studies in pure and applied science, and for this reason is frequently taken by students desiring a general scientific training.

The subjects most emphasized are mining, metallurgy, geology, mineralogy and engineering.

Metallurgy necessitates instruction in inorganic and applied chemistry, qualitative and quantitative analysis, and assaying.

Geology must carry with it preliminary training in crystallography, mineralogy, petrography, botany, zoölogy, and palæontology.

Engineering demands a fundamental knowledge of mathematics, physics, mechanics, and thermodynamics. The numerous and increasing applications of machinery to mining make it necessary to emphasize mechanical and electrical

engineering, and the proper design and construction of mining plant necessitates the study of certain branches of civil engineering.

As the graduate probably will be employed at first as a draughtsman, or as a chemist or assayer in metallurgical works, or as a surveyor, much time is given to work in the draughting-room, in the laboratories, and in the field.

The course is a severe one, and should be undertaken only by those who are well prepared physically, mentally, and by previous training, to devote themselves earnestly to the work that will be required of them.

The instruction is from text-books, and by lectures, supplemented by practical work in the laboratories, in the draughting-rooms, and in the field, and by systematic study in the mines, in the shops, and in metallurgical establishments. The summer schools constitute a very important and valuable feature of the scheme of instruction.

Graduates of colleges or scientific schools will be admitted as candidates for the degree of engineer of mines, and can usually fulfil the additional requirements for this degree in one or two years. Such men should make arrangements, if possible, to attend the summer classes in practical mining and in surveying before entrance.

The courses in metallurgical engineering and in geology and palæontology for the degrees of metallurgical engineer and bachelor of science, respectively, have much in common with the course in mining engineering. These courses devote somewhat less time to engineering and to mining, and more to metallurgy and geology, respectively. Full details will be found in the special circulars concerning these courses, which may be had upon application.

LOCATION

Numerous coal, iron, and other mines, slate and stone quarries, are easily accessible from New York in from one to four hours by rail. Magnetic iron mines in New York, New Jersey, and Pennsylvania ; hematite mines and stone quarries in the same states, and in Connecticut ; anthracite mines in Pennsylvania ; and zinc mines in New Jersey and Pennsylvania. New York and adjacent states produce each year more than half the pig-iron and coal, and over one-third of the total value of the mineral product of the whole country. New York City is the headquarters of numerous corporations operating mines and metallurgical works in this and other countries, and is one of the most important mining centres of the world. Within a radius of one hundred miles of New York City may be studied the best practice in mining under most varied conditions, and the most modern and effective mining and dressing machinery in the country. By going a little farther one may reach the bituminous coal fields and the natural gas, oil and salt regions in one direction, and the pyrites deposits and granite and marble quarries of Vermont in the other ; while the excursions of the summer class in mining extend as far as the copper and iron regions of Lake Superior, which can be reached at moderate cost by taking advantage of the steamers plying on the great lakes.

EQUIPMENT

MINING MUSEUM—The subject of mining is illustrated by collections of mine maps, working drawings, diagrams, photographs, models, mining tools, mining machines, ores and products of dressing works, and surveying apparatus.

Maps of coal and metal mines of this and other countries. Working drawings, diagrams, and photographs of mine plant, and of mining and dressing machinery. Models of mines; of shafts, tunnels, and galleries, illustrating methods of sinking, driving, timbering, tubbing, and walling. Models of deep-boring apparatus, shaft-head gear, hoisting engines, man engines, pumps, ventilators, safety cages, mine cars, crushers, stamps, ore washers, shaking tables, and other dressing machines. Mining tools and mining machines; picks, shovels, sledges, drills, blasting apparatus, lamps, safety lamps, anemometers, hand-power and machine drills. Ores and dressing products from Clausthal, Lake Superior, Missouri, and elsewhere. Surveying instruments, geological compasses and clinometers, attraction compasses, dipping needles, hanging compasses and arcs, transits, lamp signals, rods, and apparatus for plumbing and measuring shafts.

Owing to lack of room the greater part of these collections are not on exhibition at present, though available for purposes of instruction.

LECTURE ILLUSTRATIONS—The lectures on mining are illustrated by over 1,800 blue prints from negatives made for the purpose. These prints are collected in scrap-books illustrating the different courses of lectures, and each student has the use of one of these books for reference during the lecture, and for home study. These blue prints have many advantages over the usual form of lecture illustrations by lantern slides or wall diagrams. The latter are, however, used when necessary to supplement the blue prints.

ORE-DRESSING LABORATORY—Contains crushing and concentrating machinery, and the necessary apparatus for sampling and testing ores.

THE METALLURGICAL COLLECTIONS consist of 3,000 specimens illustrating the manufacture and use of fuels and fire-brick, the manufacture of iron and steel by various processes in use, and of some historical processes; collections illustrating both the ancient and the modern processes for treating ores of the metals, a large number of models of furnaces and instruments, 1,200 lecture diagrams, 1,200 lantern slides, and a very large number of working drawings used to construct works and to illustrate processes; a large number of instruments for making and observing physical tests. Pyrometers, calorimeters, and furnaces for working at high temperatures and pressures.

THE MINERALOGICAL COLLECTION consists of about 26,000 labelled specimens, and includes, in addition to the main collection, a large suite of pseudomorphs, a collection illustrating the physical character of minerals, a collection of natural crystals, and a collection of New York City minerals. Arranged in wall cases are large specimens, showing the associations of minerals. There are also three separate student collections of average specimens, more than

6,000 in number; several thousand unlabelled specimens used in determinative work, about 500 sections of minerals, and 1,500 crystal models in wood and glass.

The Geological Collection consists of over 100,000 specimens, forming the following groups: (1) A systematic series of the rocks and fossils characteristic of each geological epoch, numbering over 70,000 specimens. (2) A collection of ores, coals, oils, clays, building materials, and other useful minerals, illustrative of the course of lectures on economic geology, and believed to give the fullest representation of our mineral resources of any collection yet made. (3) A collection of 5,000 specimens of rocks, and the minerals which form rocks, to illustrate the lectures on lithology. (4) A palæontological series, which includes collections of recent and fossil vertebrates, articulates, mollusks, radiates, and plants. In this series is to be found the largest collection of fossil plants in the country, including many remarkably fine specimens, and over 200 species of which representatives are not known to exist elsewhere. Also, the most extensive series of fossil fishes in America, including many new and remarkable forms.

For the study of lithology the equipment includes very complete collections of rocks and thin sections, some thousands in all, for work in microscopic petrography, eight petrographical microscopes, micro-spectroscope, micro-camera, cameras for out-door photography, and grinder for making thin sections. The college has an arrangement with the American Museum of Natural History which secures for advanced students especial privileges in its collections. As these contain the valuable and unique collection of Palæozoic fossils made by James Hall, the privilege is of especial consequence to students of palæontology.

The department has also placed with it the geological library of the late Professor Newberry, containing many rare volumes and pamphlets.

The Physical Laboratories occupy seven large rooms, five being devoted to general physical measurements, and two to special and advanced work. These rooms are well equipped, and have accommodation for a large number of students.

The Electrical Laboratories are provided with the machinery, apparatus, and instruments of precision for electrical tests and measurements, including complete electric-lighting plants of the three principal types, and dynamos, motors, and dynamometers of various kinds; apparatus for telegraph and telephone work, measuring instruments, etc.

The Engineering Museum and Laboratories include a collection illustrating the properties of materials of new and old material which has failed under strain. The testing laboratory has three standard machines for determining tensile, compression, and transverse strength of materials. For the courses on heat and steam, numerous boilers, engines, pumps, fans, and other machines and apparatus, gauges, indicators, and dynamometers, are available for tests and experimental purposes. New facilities for making all kinds of tests are continually being added.

The Chemical Laboratories are provided with separate tables for each student, with reagents, and all the necessary apparatus, instruments, and facilities to enable the students themselves to execute the required series of qualitative and quantitative analyses.

The Assay Laboratory is provided with furnaces for crucible and muffle assays, and with crushing, concentrating, and amalgamating machinery for ore-testing on a large scale.

EXCURSIONS AND SUMMER SCHOOLS

Excursions—During the session the students may visit the different mines, machine shops, electrical and metallurgical establishments and points of geological interest of the city and its environs, and excursions for this purpose are frequently organized by the different departments.

Class in Mechanical Engineering—During the third year students may join a volunteer class in practical mechanical engineering under the supervision of the Professor of Mechanical Engineering.

Summer School in Surveying—This school is conducted during ten to twelve weeks of each summer vacation at a large farm rented for the purpose near Litchfield, Conn., where ample facilities are provided for all requisite operations, and where the topography is admirably adapted to the practical work of surveying. The operations at the summer school include numerous surveys made in squads of two men by pacing, with compass and chain, with transit and tape or telemeter, and with the plane table ; levelling, contour sketching, railroad reconnaissance and location, together with such lectures, computations, and mapping as pertain to them. About six weeks' continuous attendance is required of each class between the first and second, and the second and third years, and four weeks between the third and fourth years. The school possesses an unusually full equipment of engineers' and solar transits, levels, plane tables, compasses, and all accessories and smaller instruments. A corps of special assistants for each session aid the regular officers of the school.

Summer School in Practical Mining—The course of instruction includes six weeks spent in detailed study of the plant and methods of working at some important mine ; in geological work, surface and underground ; in mine surveying, and in excursions to other mines and mining regions.

The course of study includes shaft sinking, drifting, stoping, timbering, underground haulage, hoisting, mine drainage, ventilation, surface plant and machinery, mine buildings, shops, houses, etc., water supply, drainage, organization, and administration. The students are divided into small squads, and assigned each day to a foreman, or working gang of miners, for the study of some definite subject. Each squad of students is visited several times during the day by the instructor, who supplements the explanations of the miners, and indicates subjects demanding special study and observation. Manual labor

and the acquirement of manual dexterity by the student are subordinated to the development of his powers of observation, and to the careful and critical study of the work going on about him, and the recording of his observations and study in notes and sketches taken on the spot. The students' note-books are examined and criticised each evening. By thus carefully systematizing and directing the work of the student his time is economized, and as much ground is covered in a week as would be in a month under ordinary circumstances, and the work is done more thoroughly.

This summer school has been in successful operation since 1877, and has proved itself an indispensable adjunct to the course of instruction. It bears the same relation to the study of mining as laboratory work to the study of chemistry or physics, or clinical instruction and hospital practice to the study of medicine.

In 1893 the summer school was held at the Mount Hope and Franklin iron mines, Morris Co., N. J., and at the collieries of Messrs. Coxe Brothers & Co., at Oneida, Schuylkill Co., Pa. A visit was made also to the large strippings of the mammoth vein at Hollywood and Latimer. The last week of the session was spent at the mining exhibit of the World's Fair, Chicago.

In 1894 the summer school was held at the Tamarack and Osceola copper mines, near Calumet, Michigan. After completing the regular work, visits were made to the smelting works at Hancock and Dollar Bay, to the Tamarack concentration mill, and to the Central mine. Finally, a sixth week was occupied with the Professor of Geology in surface geological work in the same region.

Summer School in Geology—In connection with the summer school in practical mining, at least one week is devoted to practical field geology. The class is instructed in methods of field observation, locating outcrops, measuring dip and strike, keeping notes, etc., and afterwards constructing maps and geological sections from the observations noted. This instruction is given under the immediate supervision of the Professor of Geology.

COURSE OF INSTRUCTION

First Year

First Session

TRIGONOMETRY (Mathematics IV*)—4 hours, first part of session. Mr. MACLAY

ALGEBRA (Mathematics IV)—4 hours, second part of session. Mr. MACLAY

PHYSICS (Physics I)—3 hours. Professor ROOD and Mr. GORDON

CHEMISTRY (Chemistry I)—3 hours. Professor CHANDLER and Dr. WIECHMANN

QUALITATIVE ANALYSIS (Chemistry IX)—4 hours, and 4 afternoons and Saturdays, alternate weeks laboratory work. Dr. WELLS and Dr. CUSHMAN

BOTANY (Botany III)—1 hour. Professor BRITTON

BLOWPIPE ANALYSIS (Mineralogy I)—1 hour, and 5 afternoons of alternate weeks laboratory work. Professor MOSES, Dr. LUQUER and Mr. WHITLOCK

CRYSTALLOGRAPHY (Mineralogy II)—2 hours. Professor MOSES

DRAWING (Mechanical Engineering I)—1 hour lecture and drawing-room practice. Mr. MAYER and Mr. HARRINGTON

SURVEYING (Civil Engineering I)—2 hours. Mr. FOYÉ and Mr. BLACK

Second Session

ANALYTICAL GEOMETRY (Mathematics V)—4 hours. Mr. MACLAY

PHYSICS (Physics I)—3 hours. Professor ROOD and Mr. GORDON

CHEMISTRY (Chemistry I)—3 hours. Professor CHANDLER and Dr. WIECHMANN

QUALITATIVE ANALYSIS (Chemistry IX)—4 hours, and 4 afternoons and Saturdays, alternate weeks laboratory work. Dr. WELLS and Dr. CUSHMAN

BOTANY (Botany III)—1 hour. Professor BRITTON

MINERALOGY (Mineralogy III)—2 hours lectures and 1 afternoon laboratory work. Professor MOSES and Dr. LUQUER

DESCRIPTIVE GEOMETRY
DRAWING
} (Mechanical Engineering I)—2 hours, and 4 afternoons of alternate weeks drawing-room practice. Mr. MAYER and Mr. HARRINGTON

Summer Vacation

SURVEYING (Civil Engineering XIV)—Mr. FOYÉ

* See pages 14–22 for departmental statements.

Second Year

First Session

ANALYTICAL GEOMETRY AND CALCULUS (Mathematics VIII)—4 hours. Professor VAN AMRINGE

PHYSICS (Physics III)—2 hours. Professor HALLOCK

PHYSICAL LABORATORY (Physics III)—2 hours. Professor HALLOCK

APPLIED CHEMISTRY (Chemistry XXIX)—3 hours. Professor CHANDLER

ZOÖLOGY (Biology I)—1 hour. Dr. DEAN

MINERALOGY (Mineralogy III)—2 hours lectures and 1 afternoon laboratory. Professor MOSES and Dr. LUQUER

EXCAVATION AND TUNNELLING (Mining I)—3 hours. Professor PEELE

DRAWING (Mechanical Engineering I and II)—4 afternoons drawing-room practice. Mr. MAYER and Mr. HARRINGTON

Second Session

CALCULUS (Mathematics VIII)—4 hours. Professor VAN AMRINGE

PHYSICAL LABORATORY (Physics III)—2 hours. Professor HALLOCK

APPLIED CHEMISTRY (Chemistry XXIX)—3 hours. Professor CHANDLER

QUANTITATIVE ANALYSIS (Chemistry XVI)—2 hours, and 4 afternoons and Saturday laboratory practice. Professor RICKETTS and Dr. MILLER

ZOÖLOGY (Biology I)—1 hour. Dr. DEAN

OPTICAL MINERALOGY (Mineralogy VI)—2 hours lectures and 1 afternoon laboratory for 2 months. Dr. LUQUER

PETROGRAPHY (Geology V)—2 hours, and 1 afternoon for 2 months. Professor KEMP

BORING AND SHAFT SINKING (Mining II)—3 hours for 3 months. Professor PEELE

SUPPORT OF MINE EXCAVATIONS (Mining IIA)—3 hours for 1 month. Professor MUNROE

DRAWING (Mechanical Engineering I and II)—4 hours drawing-room practice. Mr. MAYER and Mr. HARRINGTON

Summer Vacation

PRACTICAL MINING (Mining XI) *optional*—5 weeks. Professor PEELE

FIELD GEOLOGY (Geology X) *optional*—1 week. Professor KEMP

SURVEYING (Civil Engineering XV)—6 weeks, field work. Mr. FOYÉ

RAILROAD SURVEYING (Civil Engineering XVI) *optional*—4 weeks, field work. Mr. FOYÉ

Third Year

First Session

Analytical Mechanics (Mechanics I)—3 hours. Professor Woodward

Assaying (Chemistry XXI)—4 hours, and 3 afternoons and Saturday laboratory practice. Professor Ricketts and Dr. Miller

Geology (Geology II)—3 hours. Professor Kemp

Resistance of Materials (Civil Engineering V)—3 hours. Professor Burr

Properties of Materials (Mechanical Engineering V)—2 hours. Professor Hutton

Mining (Mining III)—4 hours. Professor Munroe

Metallurgy (Metallurgy I)—4 hours. Professor Egleston and Dr. Struthers

Design, Problems (Civil Engineering V)—2 afternoons. Professor Burr and Mr. Foyé

Second Session

Analytical Mechanics (Mechanics I)—3 hours. Professor Woodward

Geology (Geology II)—3 hours. Professor Kemp

Resistance of Materials (Civil Engineering V)—2 hours. Professor Burr

Properties of Materials (Mechanical Engineering VI)—2 hours and laboratory work. Professor Hutton, Mr. Woolson and Mr. Gregory

Testing of Materials (Mechanical Engineering XVII)—Afternoon laboratory work. Professor Hutton, Mr. Woolson and Mr. Gregory

Engineering of Power Plants (Mechanical Engineering XVIII)—1 hour. Professor Hutton

Electrical Engineering (Electrical Engineering V)—2 hours. Professor Crocker

Electrical Engineering Laboratory (Electrical Engineering V)—2 hours. Mr. Sever

Ore Dressing (Mining IV)—4 hours for 11 weeks. Professor Munroe

Mine Constructions (Mining VIIa)—4 hours for 3 weeks. Professor Peele

Metallurgy (Metallurgy II)—4 hours. Professor Egleston and Dr. Struthers

Graphic Statics (Civil Engineering VI)—2 hours. Mr. Tuska

Design, Problems (Civil Engineering V and VI)—Afternoon work. Professor Burr, Mr. Foyé and Mr. Tuska

Vacation Class in Mechanical Engineering (Mechanical Engineering XIX) *optional*—Professor Hutton, Mr. Woolson and Mr. Gregory

Summer Vacation

Practical Mining (Mining XI)—5 weeks. Professor Peele

Field Geology (Geology X)—1 week. Professor Kemp

Railroad Surveying (Civil Engineering XVI)—4 weeks. Mr. Foyé

Fourth Year

First Session

Economic Geology (Geology III)—3 hours lectures and conferences. Professor Kemp

Thermodynamics (Mechanics IV)—3 hours. Professor Pupin

Management of Boilers (Mechanical Engineering IX)—2 hours. Professor Hutton

Heat and its Applications (Mechanical Engineering VII)—2 hours, and laboratory practice. Professor Hutton and Mr. Gregory

Motors (Mechanical Engineering XI)—1 hour. Professor Hutton

Machinery and Mechanism (Mechanical Engineering XIII)—2 hours. Mr. Woolson

Mine Engineering (Mining VI)—2 hours. Professor Munroe

Mine Plant (Mining VII)—3 hours. Professor Peele

Metallurgy (Metallurgy III)—4 hours. Professor Egleston and Dr. Struthers

Ore-dressing Laboratory (Mining V)—1 afternoon first half of term. Professor Munroe

Ore Testing (Chemistry XXIII)—1 afternoon last half of term. Professor Ricketts and Dr. Miller

Design of Mine Plant (Mining VIII)—4 afternoons. Professor Peele

Second Session

Economic Geology (Geology III)—3 hours lectures and conferences. Professor Kemp

Management of Engines (Mechanical Engineering X)—4 hours. Professor Hutton

Heat and its Applications (Mechanical Engineering VIII)—2 hours. Professor Hutton

Dynamics of Engineering (Mechanical Engineering XII)—1 hour. Professor Hutton

Machinery and Mechanism (Mechanical Engineering XIII)—2 hours. Mr. Woolson

Mine Engineering (Mining VI)—2 hours. Professor Munroe

Mine Plant (Mining VII)—2 hours. Professor Peele

Mine Surveying (Mining IX)—1 hour. Professor Munroe

Mine Administration (Mining X)—1 hour. Professor Munroe

Metallurgy (Metallurgy III)—4 hours. Professor Egleston and Dr. Struthers

Design of Mine Plant (Mining VIII)—5 afternoons. Professor Peele

Project and Thesis in Mining

DEPARTMENTS OF INSTRUCTION

Courses in Mining

I—Excavation and Tunnelling—Second year, first term. 3 hours. Professor Peele

Excavation of earth—tools and methods employed, support of excavations, special methods for quicksand and other water-bearing material ; steam shovels and other mechanical excavators ; handling and transportation of excavated material ; tables of comparative costs. Dredging—description of machines and methods for canal, river, and harbor work ; handling of dredged material ; costs of dredging. Explosives—black powder, nitro-glycerine and its compounds, and other high explosives ; their manufacture and use. Excavation of rock—hand and machine drills, methods of blasting, mammoth blasts, submarine blasting. Quarrying—plant and methods for quarrying different rocks. Tunnelling—methods of driving and timbering ; handling and transportation of excavated material ; drainage and ventilation of tunnels; submarine tunnels; permanent lining of tunnels; accidents in tunnelling ; location of tunnels.

II—Boring and Shaft Sinking—Second year, second term. 3 hours for 3 months. Professor Peele

Boring—methods and appliances for deep boring ; cable tool or oil well method ; boring with diamond drill, for prospecting and other purposes. Shaft sinking—methods and tools employed in soil and in rock ; sinking linings, or drop-shafts, and other special methods of sinking in water-bearing formations and quicksand ; handling of water and hoisting of excavated material. Shaft timbering and other systems of lining.

IIa—Mining and Support of Mine Excavations—Second year, second term. 3 hours for 1 month. Professor Munroe

Theoretical considerations, methods of breaking ground in coal and metal mining, and support of mine excavations by pillars of mineral, by timbering, by masonry, and by rock filling.

III—Exploration, Development, and Methods of Working—4 hours, third year, first term. Professor Munroe

Mineral deposits, characteristics of beds, masses, veins, and other deposits, and the irregularities and disturbances to which they are subject, as affecting the work of exploration and mining. Examination and survey of mineral properties ; relation of topography to geological structure ; construction of maps and sections ; and tracing of probable outcrops as a guide to exploration. Magnetic surveys with dip compass. Prospecting by ditches, pits, and deep boring. Development ; choice of methods ; location of openings. Working of deposits and support of excavations ; methods applicable to deposits of different thickness, inclination, and character. Coal mining ; vein mining ; working of thick deposits and soft-ore bodies. Salt mining. Support of special excavations. Surface workings.

IV—Ore Dressing and the Mechanical Preparation of Coal—4 hours for 11 weeks, third year, second term. Professor Munroe

The general principles and theory of dressing ; preliminary operations ; hand dressing ; cleansing ; crushing ; jigging with and without preliminary sizing ; slime concentration ; and description of typical dressing works and coal-washing plants in this country and abroad.

V—Ore-dressing Laboratory—1 afternoon for seven weeks, first term, fourth year. Professor Munroe

During the second term of the fourth year a portion of the time assigned to ore testing is devoted to the mechanical assaying of ores and coal by hand-jigging and vanning.

VI—Mine Engineering—2 hours, fourth year. Professor Munroe

Extraction ; methods and machinery ; handling mineral in working places ; underground haulage. Surface handling and transportation ; arrangements for loading and unloading cars and vessels, and for storing of minerals. Mineral railroads. Common roads. Drainage ; sources of mine waters ; methods for the control and raising of water ; dams ; drainage levels. Water supply. Ventilation ; air of mines ; mine gases ; methods of ventilation ; control and measurement of air currents. Accidents to men in shafts, levels, and working places ; fire-damp and dust explosions ; mine fires ; inundations ; rescue and relief of men.

VII—Mine Plant—3 hours, first term, and 2 hours, second term, fourth year. Professor Peele

Descriptions and critical discussion of the machinery employed in hoisting, drainage, and ventilation ; air-compressing plant ; types of plant best adapted to different conditions ; erection and care of machinery ; accidents, breakage, and repairs.

Lectures are given also upon the design of timber, masonry, and iron constructions, head-frames, hoisting cages, ventilating fans, mine buildings, and other portions of mining plant.

VIIa—Mine Constructions—4 hours for 3 weeks, second term, third year. Professor Peele

Building-stones ; brick ; limes ; cements and concretes. Foundations in various soils ; masonry and timber construction, with special reference to mine work ; mine buildings ; trestles, etc.

VIII—Design of Mine Plant—4 afternoons, first term, and 5 afternoons, second term, fourth year. Professor Peele

The drawings required are planned to form a part of the graduating projects of the class, comprising the design and construction of plant in connection with the development of a mine. The project subjects, with their governing conditions, are assigned, and the work is begun, in the third vacation, during the session of the summer school in mining. This work supplements the lectures on mine plant and its design, involving reading and study, and the preparation of working drawings, bills of material, and estimates. The work is done under constant supervision and advice in the draughting-room.

IX—Mine Surveying—1 hour, second term, fourth year. Professor Munroe

This course supplements the practical work in underground surveying in connection with the summer school in mining. It includes the general principles of underground surveying, the construction of mine maps and sections, the measurement of contracts, the location of lines for new work.

X—Administration and Mine Accounts—1 hour, second term, fourth year. Professor Munroe

Administration, organization, and business management, mine accounts, and cost sheets. Examination and valuation of mines.

Summer School

XI—The Summer School in Practical Mining is held in June and July, at some mine selected for the purpose, in the vacation between the third and fourth years, and lasts six weeks, including one week field geology. Professor Peele and Assistant in Mining.

Graduate Courses

Special courses, consisting of personal instruction, reading, and experimental investigation, will be arranged for advanced students according to their individual needs. These courses vary in difficulty and in the amount of time necessary, according as the student is a candidate for the degree of A.M. or Ph.D., and according as he pursues mining as a major or a minor subject. The following are suggested :

XII—Coal Mining—2 hours.

XIII—Ore Mining—2 hours.

XIV—Coal Washing—1 hour.

XV—Ore Dressing—1 hour.

XVI—Examination of a Mineral Property, or a Mine—4 to 6 weeks devoted to field and underground work in the summer school of practical mining, with conferences at convenience of professor.

XVII—Examination of a Coal-washing Plant, or an Ore-dressing Plant—4 to 6 weeks' work in the mill and in the laboratory, with conferences.

XVIII—Special Problems and Original Investigations in Ore Dressing and Mining as Assigned—With conferences, laboratory, and field work as required.

Course in Biology

I—Elementary Zoölogy—Introductory to biology, palæontology, geology. Descriptive of the various orders of animals. Lectures and demonstrations. Text-book : Packard's Elements of Zoölogy. 1 hour. Dr. Dean

Course in Botany

III—General Botany—Description of the principal features of plant physiology and anatomy, and of the principal characteristics of the subkingdoms and classes. Text-book : Bastin's College Botany. 1 hour. Professor Britton

Courses in Chemistry

I—General Inorganic Chemistry—Introduction: Laws of chemical combination, history, occurrence, preparation and properties of the elements and their principal compounds. Text-books: Fownes' Manual of Chemistry, or Newth's Inorganic Chemistry. 2 lectures and 1 recitation. Professor Chandler and Dr. Wiechmann

IX—Qualitative Analysis—Lectures, recitations, and laboratory practice. Text-book: Fresenius' Qualitative Analysis. 2 lectures, 2 recitations, and laboratory practice four afternoons and Saturdays, alternate weeks. Dr. Wells and Dr. Cushman

XVI—Quantitative Analysis—Text-books: Cairns' Quantitative Analysis and Fresenius' Quantitative Analysis. 1 lecture, 1 recitation, and 15 hours laboratory practice. Professor Ricketts and Dr. Miller

XXI—Assaying—Ores and metallurgical products. Text-book: Ricketts' Notes on Assaying. 2 lectures, 2 recitations, and laboratory practice 15 hours, first term. Professor Ricketts and Dr. Miller

XXIII—Ore Testing for the Proper Selection of Methods of Treatment—Conferences and laboratory practice one afternoon for one-half of the first term. Professor Ricketts and Dr. Miller

XXIX—Applied Chemistry, General Course—The subjects discussed are: (1) Air—nature, sources of contamination, sewer gas, plumbing, draining, disinfection, ventilation. (2) Water—composition of natural waters, pollution, disposal of sewage and house refuse. (3) Artificial illumination—candles, oils, and lamps, petroleum, gas, and its products, electric light. (4) Limes, mortars, and cements. (5) Building-stones—decay and preservation. (6) Timber and its preservation—pigments, paints, essential oils, varnishes, preserving processes. (7) Explosives—gunpowder, gun-cotton, nitro-glycerine. (8) Glass and ceramics. (9) Electro-metallurgy. (10) Photography. Text-books: Park's Hygiene and Wagner's Chemical Technology. 3 lectures. Professor Chandler

Courses in Civil Engineering

I—Theory of Surveying—Compass surveying—Farm surveying with preliminary work—Computations. Lectures and recitations 2 hours first term, first year. Reference books: Johnson's Theory of Surveying and Davies' Surveying. Mr. Foyé and Mr. Black

V—Elasticity and Resistance of the Materials of Engineering—Laws of elasticity in homogeneous materials—Co-efficients of elasticity—Relations between stresses and strains—Common and exact theories of torsion and flexure—Elastic limits, working stresses, and ultimate resistances of wrought-iron, cast-iron, steel, alloys, timbers, building-stones, cement, concrete, and masonry—Complete treatment of simple and continuous beams—The design and construction of iron, steel, and timber columns and beams, including the design and construction of plate girders—Shafts—Cables—Fatigue of materials—Specifications. 3 hours lectures and recitations during the first term, and 2

hours during the second term, third year. 5 hours first term, and 5 hours second term, of problem and design work, are required in the drawing academy. Reference and text-book: Burr's Elasticity and Resistance of Material. Professor BURR

VI—GRAPHIC STATICS—Equilibrium polygon, and polygonal frames for all systems of loads—Graphical representations of shears and moments for both non-continuous and continuous beams—Fixed and moving loads—Applications to bridge and railway trusses. 2 hours lectures during the second term, third year. 5 hours of problem and design work are required in the drawing academy. Reference book: Hoskin's Graphic Statics. Mr. TUSKA

XIV—SURVEYING BETWEEN THE FIRST AND SECOND YEARS—Pacing, chaining, and ranging—Farm survey—Adjustment of instruments—Angle reading by repetition—Repetition traverse. Daily lectures, field and office work. Mr. FOYÉ

XV—SURVEYING BETWEEN THE SECOND AND THIRD YEARS—Azimuth traverse—Levelling—Topographical survey with plane table—City surveys—Contour sketching. Daily lectures, field and office work. Mr. FOYÉ.

XVI—SURVEYING BETWEEN THE THIRD AND FOURTH YEARS—Railroad surveying—Reconnaissance—Preliminary survey—Location—Cross-sectioning—Computations—A complete survey and location of a line two to five miles long are made, with all the attendant computations requisite for placing the work under contract. Daily lectures, field and office work. Mr. FOYÉ

Course in Electrical Engineering

V—ELECTRICAL ENGINEERING—The principles of electrical engineering and their application to general engineering. 2 hours lectures and 2 hours laboratory work, second term. Professor CROCKER and Mr. SEVER

Courses in Geology

II—GENERAL GEOLOGY—First term, physical geology, with practical work in the rock collections under the lithological part of the subject; second term, stratigraphical and historical geology, involving laboratory work with type fossils and collections illustrating the geology of the United States. Text-book: Dana's Manual of Geology. 3 hours lectures. Professor KEMP

III—ECONOMIC GEOLOGY—First term, discussion of the general features and formation of ore bodies, followed by a description of the deposits of the ores of iron, copper, lead, zinc, silver, gold, and the lesser metals, with especial reference to North America; second term, a description of the distribution and occurrence of coal, petroleum, natural gas, asphalt, building-stone, water supply, salines, and minor minerals. Text-book: Kemp's Ore Deposits of the United States, and lecture notes privately printed. 3 hours lectures and conferences. Professor KEMP

V—PETROGRAPHY—A short course in the microscopic study of rocks. Follows Mineralogy VI. 2 lectures and one afternoon two months of the second term. Professor KEMP

Summer School

X—The summer school in geology is held in connection with the summer school in practical mining, and at least one week is devoted to field work. During the college year excursions are offered to points of geological interest near New York, on all Saturdays and holidays of the fall and spring. Few other localities afford so extensive and so accessible exposures as the vicinity of New York. Professor Kemp

Courses in Mathematics

IV—Trigonometry, Plane, Analytical and Spherical (Davies' Legendre), and Algebra (Peck's) from Series—4 hours, first term. Mr. Maclay

V—Analytical Geometry (Wentworth's) through the Hyperbola—4 hours, second term. Mr. Maclay

VIII—Analytical Geometry (Wentworth's) from the Loci of the Second Order, and Differential and Integral Calculus (Osborne's)—4 hours. Professor Van Amringe

Courses in Mechanical Engineering

I—Elementary Mechanical Drawing—Use of instruments, elementary projections, and descriptive geometry. 1 hour lecture and drawing-room practice, first term, 2 hours lectures and four afternoons, second term, alternate weeks in the first year; four afternoons drawing academy, alternate weeks, first term, and 4 hours practice, second term, in the second year. Mr. Mayer and Mr. Harrington

II—Specialized Engineering Drawing—Topographical and geological, charts and map; working and isometric drawing of machinery, furnaces, and structural work. Tracing and blue printing, and shop drawings. Afternoon practice drawing academy. Mr. Mayer and Mr. Harrington

V—Properties of Materials—General properties of all materials used in engineering, castings, and ingot metals. 2 hours lectures, first term. Professor Hutton

VI—Properties of Materials—Wrought-iron and steel, fabrication and shop processes. Inspection of product, and tests of materials; structural alloys. 2 hours lectures, second term; laboratory work with testing machines. Professor Hutton, Mr. Woolson and Mr. Gregory

VII—Heat and its Applications—Fuels for motive power, transfer of heat, generation of steam, chimneys, artificial draft, use of steam in engines. 2 hours lectures, first term; laboratory practice. Professor Hutton and Mr. Gregory

VIII—Heat and its Applications—Gas and air engines, combined vapor engines, ammonia and other vapor engines, air compressors, refrigerating machinery. 2 hours lectures, second term. Professor Hutton

IX—Design and Management of Boilers—Construction, typical forms, setting, running, tests, and inspection. 2 hours lectures, first term. Professor Hutton

X—Design and Management of Engines—Construction, valve-gear, mechanisms, handling, erection, and repair. 4 hours lectures, second term. Professor Hutton

XI—Motors Other than Steam—Animal, water, wind, and wave motors; turbines. 1 hour lecture, first term. Professor Hutton

XII—Dynamics—Work of motors, friction, efficiency, dynamometers, governors, and regulators. 1 hour lecture, second term. Professor Hutton

XIII—Machinery and Mechanism—Motion, velocity, transmissive principles, conversion of motion, teeth of wheels, general mechanism. 2 hours lectures. Mr. Woolson

XVII—Testing of Materials of Engineering—Determinations of tensile, compressive, transverse, and torsional resistances; constants of formulæ; abrasive and frictional qualities of alloys. Laboratory work. Professor Hutton, Mr. Woolson and Mr. Gregory

XVIII—Engineering of Power Plants—Steam engines and their mechanism, rotary engines, valve-gear, and construction. 1 hour lecture, second term. Professor Hutton

XIX—Vacation Class in Mechanical Engineering—During the latter half of the school year visits are made to shops, factories, iron and steel works, and pumping stations, for the study of practice in these lines. The time occupied during the third year is variable according to circumstances. The instruction is conducted by Professor Hutton, Mr. Woolson and Mr. Gregory

Courses in Mechanics

I—Analytical Mechanics—As a text for this subject, Rankine's Applied Mechanics is used; attention being confined chiefly, however, to Part I, Principles of Statics (including hydrostatics); Part III, Principles of Kinematics; and Part V, Principles of Dynamics (including hydrodynamics). This text is supplemented by lectures on special topics, by written solutions and discussions of typical problems, and by demonstrations with the aid of apparatus. Particular attention is given to the doctrine of units and dimensions of units, and to problems affording actual applications of principles. 3 hours. Professor Woodward

IV—Thermodynamics, with special reference to its bearing on the theory of caloric engines. 3 hours, first term. Professor Pupin

Courses in Metallurgy

I—General Metallurgy—As an introduction to Courses II and III, history, definition of terms, calorimetry, refractory materials, furnaces, fuels (natural and artificial), chimneys, blast engines, regulators, hot-air stoves, tuyeres, pyrometry, furnace-gas analysis.

Text-books: Percy's Metallurgy of Fuels, Iron, and Steel; Bauermann's Metallurgy of Iron; Greenwood's Metallurgy of Iron and Steel; Egleston's Metallurgical Tables. 3 hours lectures and 1 hour review, first term. Professor EGLESTON and Dr. STRUTHERS

II—THE METALLURGY OF IRON AND STEEL—*Cast-iron:* Discussion of ores, effect of impurities, construction of the blast furnace and auxiliary apparatus. Theory of the process, detailed discussion of practice, slags, calculation of charges, foundry practice, malleable cast-iron.

Weld Iron: Properties, effect of impurities, knobbling process, German process, fining, puddling, rolls, shears, hammers, piling, reheating, and general mill-work.

Direct methods for wrought-iron: Catalin, Bloomary, Chenot, Blair and other processes.

Steel: General description, effect of impurities, direct methods of manufacture, cementation process, crucible process, acid open-hearth process, acid Bessemer process, basic open-hearth process, basic Bessemer process, pit practice of handling ingots, general mill-work, including reheating, rolling, rails, tires, wire, and uses of scrap steel.

Text-books: H. M. Howe's Metallurgy of Steel; Percy's Metallurgy of Fuels, Iron, and Steel; Greenwood's Metallurgy of Iron and Steel; Egleston's Metallurgical Tables. 3 hours lectures and 1 hour review, second term. Professor EGLESTON and Dr. STRUTHERS

III—METALLURGY OF THE METALS—*Copper:* Properties, effect of impurities, ores, roasting, shaft-furnace treatment, reverberatory-furnace treatment, treatment of native ores at Lake Superior, treatment of pure and poor sulphide ores, treatment of impure sulphide ores, Bessemerizing copper matter, treatment of oxides, wet processes, condensation and treatment of furnace gases, electrolytic refining processes.

Lead: Properties, effect of impurities, ores, roasting and reaction process, roasting and reduction process, precipitation processes, desilverization, refining.

Silver: Ores, roasting furnaces, fusion processes, amalgamating processes, wet processes, desilverization, cupellation, refining.

Gold: Ores, hand and machine hydraulic processes, stamp milling, parting processes, chlorination processes, cyanide process.

Zinc: Properties, ores, English, Belgian, and Silesian processes, refining and mechanical treatment.

Tin: Properties, ores, mechanical treatment, reverberatory and shaft-furnace processes, refining.

Mercury: Properties, ores, treatment in Austria, Spain, and California.

Bismuth: Distillation process, refining.

Arsenic: Distillation process, refining.

Antimony: Processes, refining.

Nickel and Cobalt: Concentration, separation, refining.

Aluminium: Furnace and electrolytic processes.

Text-books: E. D. Peter's, Jr., American Methods of Copper Smelting; H. O. Hofman, Lead Smelting; T. Egleston, Metallurgy of Gold, Silver,

and Mercury. 3 hours lectures and 1 hour review. Professor EGLESTON and Dr. STRUTHERS

Courses in Mineralogy

I—BLOWPIPE ANALYSIS—The tests for 40 elements and the qualitative analysis of minerals, alloys, and slags. 1 hour conference, and afternoons of alternate weeks laboratory, first term. Professor MOSES, Dr. LUQUER and Mr. WHITLOCK

II—CRYSTALLOGRAPHY—History, general characters, laws, forms, simple measurements, and calculations. Lectures and conferences 2 hours, first term. Professor MOSES

III—DESCRIPTIVE AND DETERMINATIVE MINERALOGY—Study of 200 important species, their properties, uses, and methods of determination. 2 hours lectures, one afternoon laboratory, second term of first year and first term of second year. Professor MOSES and Dr. LUQUER

VI—OPTICAL MINERALOGY—Introductory to Geology V. 2 lectures and 1 afternoon, for two months of second term of second year. Dr. LUQUER

Courses in Physics

I—GENERAL PHYSICS—Sound and Heat (first term). Light and Electricity (second term). 3 hours lectures and recitations. Professor ROOD and Mr. GORDON

III—ELECTRICITY (first term)—Lectures on absolute system of mechanical and electrical units; electrical measurements; the derivation and use of the Ampere, Volt, Ohm, Watt and Joule. 2 hours. Professor HALLOCK

LABORATORY WORK IN GENERAL PHYSICS—2 hours, both terms. Professor HALLOCK

Columbia University in the City of New York

SCHOOLS OF MINES, CHEMISTRY, ENGINEERING, AND ARCHITECTURE

GENERAL INFORMATION

1896–97

NOTE

Columbia University offers the following courses:

In Columbia College:

A four-years' course leading to the degree of . . . A.B.

In the School of Law:

A three-years' course leading to the degree of . . . . LL.B.

In the School of Medicine (College of Physicians and Surgeons):

A four-years' course leading to the degree of . . . . M.D.

In the School of Mines:

A four-years' course in Mining Engineering leading to the degree of					E.M.
"	"	Metallurgy	"	"	Met.E.

In the School of Chemistry:

A four-years' course in Analytical and Applied Chemistry leading to the degree of . . . . B.S.

In the School of Engineering:

A four-years' course in Civil Engineering leading to the degree of					C.E.
"	"	Sanitary Engineering	"	"	C.E.
"	"	Electrical Engineering	"	"	E.E.
"	"	*Mechanical Engineering	"	"	Mech.E.

*The course in Mechanical Engineering will be offered for the first time in 1897, or upon removal to the new site.

In the School of Architecture:

A four-years' course in Architecture leading to the degree of . B.S.

Also many courses under the various faculties, especially the Faculties of Applied Science, Political Science, Philosophy, and Pure Science, leading to the university degrees of A.M. and Ph.D. A combination of courses under the Faculties of Law and Political Science leads to the degree of LL.M.

The first-year courses of the School of Law, the School of Medicine, the School of Mines, the School of Chemistry, the School of Engineering, and the School of Architecture, are open, as electives, to Seniors in the College. Consequently, such Seniors as may desire to do so can prepare themselves for advanced standing in these schools by electing these first-year courses and counting them for the degree of A.B.

Information and circulars as to any of the above courses may be had by addressing the Secretary of the University.

The catalogue of the University is published in December and is sold at twenty-five cents a copy.

All the schools and departments of Columbia University are at Madison Avenue and 49th Street, with the exception of the department of Zoölogy and the School of Medicine, which are at Tenth Avenue and 59th Street.

Unless unexpectedly prevented, the University will open in October, 1897, upon the new site, 116th Street and Amsterdam Avenue, Morningside Heights.

may15-96-30000

FACULTY OF APPLIED SCIENCE

The Faculty of Applied Science has charge of the following professional schools:

SCHOOL OF MINES
SCHOOL OF CHEMISTRY
SCHOOL OF ENGINEERING
SCHOOL OF ARCHITECTURE

The following departments are represented in the faculty:

ARCHITECTURE	GEOLOGY
ASTRONOMY	MATHEMATICS
CHEMISTRY	MECHANICS
CIVIL ENGINEERING	MINERALOGY and METALLURGY
ELECTRICAL ENGINEERING	MINING
MECHANICAL ENGINEERING	PHYSICS

PRESIDENT

SETH LOW, LL.D. . . . . Columbia University

Officers of the Faculty in the University Council

CHARLES F. CHANDLER, Ph.D., M.D., LL.D.
(*Dean, Faculty of Applied Science*) *ex-officio Member*

HENRY S. MUNROE, E.M., Ph.D. . . . . . *Elected Delegate*

Standing Committees

COMMITTEE ON ADMISSIONS AND EXAMINATIONS: Professors Chandler, Van Amringe, Munroe

COMMITTEE ON SPECIAL STUDENTS: Professors Chandler, Hutton, Hamlin

OFFICERS OF INSTRUCTION

Professors

NAMES	ADDRESSES
THOMAS EGLESTON, E.M., Ph.D., LL.D. Professor of Mineralogy and Metallurgy	35 Washington Square, West
CHARLES F. CHANDLER, Ph.D., M.D., LL.D. Professor of Chemistry and Dean of the Faculty	51 East 54th Street
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OGDEN N. ROOD, A.M. Professor of Physics	Columbia University
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FREDERICK R. HUTTON, A.M., C.E., Ph.D. Professor of Mechanical Engineering	296 Lexington Avenue
JOHN KROM REES, A.M., E.M., Ph.D. Professor of Astronomy and Director of the Observatory	1 West 72d Street
PIERRE DEPEYSTER RICKETTS, E.M., Ph.D. Professor of Analytical Chemistry and Assaying	115 East 79th Street
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ALFRED J. MOSES, E.M., Ph.D. Adjunct Professor of Mineralogy	9 Henderson Place
CHARLES E. COLBY, E.M., C.E. Adjunct Professor of Organic Chemistry	1933 Madison Avenue
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ROBERT PEELE, E.M. Adjunct Professor of Mining	Morningside Park, corner of 114th Street

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WILLIAM H. BURR, C.E. . . . . . . Professor of Civil Engineering	151 West 74th Street
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HAROLD JACOBY, A.B. . . . . . . Adjunct Professor of Astronomy	15 West 53d Street

Instructors

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ALEXIS A. JULIEN, A.M., Ph.D. . . . . . Instructor in Microscopy and Microbiology	Columbia University
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RALPH E. MAYER, C.E. . . . . . . Instructor in Drawing	71 East 85th Street
IRA H. WOOLSON, E.M. . . . . Instructor in Drawing	Astoria, L. I.
CHARLES A. HARRIMAN . . . . . . Instructor in Architectural Drawing	New Rochelle, N. Y.
BASHFORD DEAN, A.M., Ph.D. . . . . Instructor in Biology	20 West 82d Street
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JAMES MACLAY, C.E. . . . Instructor in Mathematics	312 Summer Avenue, Newark, N. J.

Tutors

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LOUIS H. LAUDY, Ph.D. Tutor in General and Applied Chemistry	Columbia University
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HENRY C. BOWEN Tutor in Quantitative Analysis	212 East 50th Street
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LEA McI. LUQUER, C.E., Ph.D. Tutor in Mineralogy	Columbia University
WILLIAM H. FREEDMAN, C.E., E.E. Tutor in Mechanics	157 West 119th Street
HERMANN T. VULTÉ, Ph.D. Tutor in Chemistry	33 Park Avenue, New Rochelle, N. Y.
CHARLES A. HOLLICK, Ph.B. Tutor in Geology	New Brighton, S. I.
HERSCHEL C. PARKER, Ph.B. Tutor in Physics	21 Fort Greene Place, Brooklyn, N. Y.
EDMUND H. MILLER, A.M., Ph.D. Tutor in Analytical Chemistry and Assaying	118 West 11th Street
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CHARLES P. WARREN, A.M. Tutor in Architectural Construction	101 West 78th Street
CARLTON C. CURTIS, Ph.D. Tutor in Botany	118 Bergen Street, Brooklyn, N. Y.
HERMAN S. DAVIS, Ph.D. Tutor in Astronomy	Columbia University

Assistants

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HERBERT T. WADE, A.B. Assistant in Physics	149 East 46th Street
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THOMAS H. HARRINGTON, C.E. Assistant in Mechanical Engineering	Westchester, N. Y.
ADOLPH BLACK, C.E. Assistant in Civil Engineering	1434 Lexington Avenue
GEORGE H. LING, A.M. Assistant in Mathematics	675 Lexington Avenue
GEORGE B. GERMANN, A.B. Assistant in Mathematics	90 Norman Avenue, Brooklyn, N. Y.
HENRY E. KEYES, Ph.D. Assistant in Physics	102 Waverley Place
CHARLES E. PELLEW, E.M. Assistant in Applied Chemistry	51 East 54th Street

Curators

MAXIMILIAN K. KRESS, A.M. Curator and Lecturer in Architecture	248 West 42d Street
GILBERT VAN INGEN Curator of the Geological Collections	244 East 50th Street
JOHN K. SMALL, A.B., Ph.D. Curator of the Herbarium	608 Lexington Avenue

Registrar

GEORGE F. FISHER	Columbia University

COURSES OF STUDY

Columbia University offers opportunity for the study of science in several faculties and schools, namely:

1. In Columbia College, the undergraduate department of the University.
2. In the School of Mines, the School of Chemistry, the School of Engineering, and the School of Architecture, which are professional schools under the charge of the Faculty of Applied Science.
3. In the university courses conducted by the Faculty of Applied Science, and by the Faculty of Pure Science.

Collegiate Preparation Recommended

Candidates intending to enter the School of Mines, the School of Chemistry, the School of Engineering, or the School of Architecture, are recommended to take advantage of the opportunities offered in Columbia College, the undergraduate department of the University, under the new curriculum, which goes into effect in 1897. By a proper choice of studies under this curriculum students, at the end of four years, will obtain the degree of Bachelor of Arts, and can at the same time prepare themselves to enter the third year of either of the professional schools, and take their technical degrees two years later. As students may and do enter the College two years earlier than they enter the professional schools, students taking this combined course of study will be able to obtain the professional degree at the same age as though they entered the professional school in the first instance at the present average age of such students, with the added advantage that they will have had at the same time the elements of a liberal education before they enter upon a strictly professional course of study. This combined six-year course is strongly urged and recommended, for the reason that engineers, chemists, and architects, as professional men, need the liberal training offered by a collegiate course quite as much as do lawyers, physicians, or clergymen. Experience has shown that those who have taken a liberal course of study in the past, and who have enjoyed the advantages of such an education before beginning their technical studies, have taken a much higher standing in their profession, have exercised greater influence in the community, and have been much more useful men than those who have relied upon a purely scientific or professional course of study.

Without sacrificing the necessary elements of a liberal education, the widest opportunity for elective work in science is offered in this new curriculum which will permit the student to pursue almost any desired line of study and to specialize in it to almost any desired extent. A properly chosen course of study in the College will thus fit students for advanced work and original investigation, and is to be recommended to candidates for higher degrees under the Faculty of Applied Science, or the Faculty of Pure Science.

Details of the courses of study to be offered will be found in the Columbia College circular, which will be sent on application to the Secretary of the University.

Courses in Applied Science

The Faculty of Applied Science has charge of the following schools :

1 The SCHOOL OF MINES, with four-years' courses leading to the degrees of Engineer of Mines and Metallurgical Engineer.

2 The SCHOOL OF CHEMISTRY, with a four-years' course in Analytical and Applied Chemistry leading to the degree of Bachelor of Science.

3 The SCHOOL OF ENGINEERING, with four-years' courses in Civil Engineering, Sanitary Engineering, Electrical Engineering, and Mechanical Engineering, the first two leading to the degree of Civil Engineer, and the others to the degrees of Electrical Engineer and Mechanical Engineer respectively.

4 The SCHOOL OF ARCHITECTURE, with a four-years' course leading to the degree of Bachelor of Science.

These courses are intended to meet the requirements of the several professions indicated. Many of the courses permit a certain amount of specialization, particularly in the fourth year. The courses in the School of Mines are so arranged that the student can emphasize the engineering, the metallurgical, or the geological side of his profession, while one of the alternative courses in Mechanical Engineering is designed for those who wish to make a specialty of mine plant and machinery. A course in Sanitary Engineering (leading to the degree of Civil Engineer) is provided for those who wish to emphasize this important branch of civil engineering. The Mechanical Engineering course offers three alternatives in the fourth year, emphasizing respectively the dynamic, the electrical, and the mining side of the mechanical engineer's work. The School of Architecture offers two alternatives in the fourth year, a course of Advanced Architectural History and Design, and a course of Advanced Architectural Engineering and Practice. Full particulars regarding each of these courses of study are contained in special circulars which will be forwarded on application to the Secretary of the University.

University Courses in Applied Science

The Faculty of Applied Science has charge of candidates for the degrees of Master of Arts and Doctor of Philosophy who desire to undertake advanced study or special investigations in mining, metallurgy, engineering (civil, sanitary, electrical, and mechanical), or in architecture. A circular giving details of these courses may be obtained on application to the Secretary of the University.

University Courses in Pure Science

The Faculty of Pure Science has charge of all advanced work leading to the degrees of Master of Arts and Doctor of Philosophy in the physical sciences (chemistry, physics, and chemical physics) ; in the mathematical sciences (pure mathematics, mechanics, mathematical physics, astronomy, and geodesy) ; and in the natural sciences (mineralogy, lithology, geology, botany, zoölogy, palæontology, and physiology). A circular giving details of these courses may be obtained on application to the Secretary of the University.

BY-LAWS

1 At the beginning of the first year each student must elect which of the seven courses he intends to pursue, and must thenceforth abide by his election unless permitted by the faculty to make a change.

2 No student is allowed to pursue more than one course at a time.

Admission

3 Candidates for admission to the first class, at its formation, must be of the age of *eighteen years*, complete; and for admission to advanced standing there will be required a corresponding increase of age; but this rule may be dispensed with when, in the opinion of the faculty, there are sufficient reasons to justify its relaxation.

Enrolment and Certificates

4 An applicant for admission must file with the Dean of the Faculty of Applied Science, at least one week before the day fixed for the entrance examinations, a certificate from his principal instructor containing a definite statement of the subjects which he is qualified to offer for examination.

No student will be examined in June, 1896, whose name is not enrolled and whose certificate is not filed on or before Wednesday, June 3d, of the same year; nor will any student be examined in September, 1896, whose name is not enrolled and whose certificate is not filed on or before Monday, September 21st. No student will be examined in June, 1897, whose name is not enrolled and whose certificate is not filed on or before Wednesday, June 2d, of the same year; nor will any student be examined in September, 1897, whose name is not enrolled and whose certificate is not filed on or before Monday, September 20th.

Blank forms of the certificate required can be had upon application to the Registrar. In the case of students expecting to be examined at a distance from the College, the names must be enrolled and the certificates filed one week earlier.

5 Every candidate must, before admission, present a certificate of good moral character from his last teacher, or from some citizen in good standing, and students from other colleges must bring certificates from those colleges of honorable dismission.

Entrance Examinations

6 Candidates for the first class must pass satisfactory examinations in:

Mathematics:

Arithmetic, including the metric system of weights and measures.

Algebra, on the fundamental operations, greatest common divisor and least common multiple, fractions, equations of the first degree, formation of powers, extraction of roots, radicals, equations of the second degree, ratio, proportion, and series.

Geometry, plane, solid, and spherical geometry.

Plane trigonometry, on the use of tables of logarithms of numbers and of logarithms of trigonometric functions, solution of right-angled and of oblique-angled plane triangles.

Physics:

On the equivalent of Ganot's smaller treatise (Peck's Ganot's Natural Philosophy).

Chemistry:

On the non-metallic elements and their important compounds with each other, as given in the ordinary high-school text-books.

English—requirements for 1896:

Grammar—(Whitney's Essentials of English Grammar indicates the field to be covered).

Composition—The candidate will be required to write an essay of at least two hundred and fifty words, based upon some subject taken from one of the four works in English literature prescribed for the year. The essay must be written during the examination, and will be judged with reference to spelling, punctuation, grammar, division by paragraphs, and expression.

For 1896 the works prescribed are:

Shakspere's Merchant of Venice; Milton's L'Allegro and Il Penseroso; Longfellow's Evangeline; Macaulay's Essay on Milton; and Webster's first Bunker Hill Oration.

In 1897 and succeeding years candidates will be examined in accordance with the requirements stated as follows. In both the spring and the autumn examinations of 1896 a candidate may choose whether he will be examined in accordance with the requirements now in force (as stated *above*) or in accordance with the new requirements.

English—requirements for 1897:

No applicant will be accepted in English whose work is notably defective in point of spelling, grammar, idiom, punctuation, or division into paragraphs.

1 Reading and Composition—The candidate will be required to present evidence of a general knowledge of the subject-matter of the prescribed books, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics, to be chosen by the candidate from a considerable number—perhaps ten or fifteen—set before him in the examination paper. The treatment of these topics is designed to show the candidate's power of clear and accurate expression, and will call for only a general knowledge of the substance of the books. In the place of a part or whole of this test, the candidate may present an exercise book, properly certified by his instructor, containing compositions or other written work done in connection with the reading of the books.

The candidate is expected to read intelligently all the books prescribed. He should read them as he reads other books; he is not expected to know them minutely, but to have freshly in mind their most important parts.

The books set for this part of the examination will be:

1896: Shakspere's A Midsummer Night's Dream; Defoe's History of the Plague in London; Irving's Tales of a Traveller; Scott's Woodstock; Macaulay's Essay on Milton; Longfellow's Evangeline; George Eliot's Silas Marner.

1897: Shakspere's As You Like It; Defoe's History of the Plague in London; Irving's Tales of a Traveller; Hawthorne's Twice Told Tales; Longfellow's Evangeline; George Eliot's Silas Marner.

1898: Milton's Paradise Lost, Books I and II; Pope's Iliad, Books I and XXII; The Sir Roger de Coverley Papers in The Spectator; Goldsmith's The Vicar of Wakefield; Coleridge's Ancient Mariner; Southey's Life of Nelson; Carlyle's Essay on Burns; Lowell's Vision of Sir Launfal; Hawthorne's The House of the Seven Gables.

2 Study and Composition—This part of the examination presupposes the thorough study of each of the works named below. The examination will be upon subject-matter, literary form, and grammatical and logical structure.

In connection with the reading and study of the required books, parallel or subsidiary reading should be encouraged, and a considerable amount of English poetry should be committed to memory. The essentials of English grammar should not be neglected in preparatory study.

The books prescribed are for the present to be those selected and recommended by the Association of Colleges and Preparatory Schools in the Middle States and Maryland, and similar bodies, acting jointly.

The books set for this part of the examination will be:

1896: Shakspere's The Merchant of Venice; Milton's L'Allegro, Il Penseroso, Comus, and Lycidas; Webster's first Bunker Hill Oration.

1897: Shakspere's The Merchant of Venice; Burke's Speech on Conciliation with America; Scott's Marmion; Macaulay's Life of Samuel Johnson.

1898: Shakspere's Macbeth; Burke's Speech on Conciliation with America; De Quincey's The Flight of a Tartar Tribe; Tennyson's The Princess.

French:

The elements of French grammar.

The ability to read easy French, such as Rambaud's Petite Histoire de la Civilisation Française.

The admission examination in French is divided into two parts designed to test, respectively (1st), the ability of the applicant to read at sight French prose of ordinary difficulty; (2d), his knowledge of elementary grammar.

The ability to read ordinary French prose will be acquired, it is believed, by the reading, in addition to the study of Grammar, of three hundred or more 12mo pages of French. It is recommended that the reading be divided between historical narrative and popular works on science, including the names of most of the articles in daily use; a few very simple descriptive passages may also be included. Although no work is prescribed, the attention of teachers in preparatory schools is called to Alfred Rambaud's Petite Histoire de la Civilisation Française (Paris, A. Colin), and Louis Figuier's Les Grandes Inventions (Paris, Hachette).

By knowledge of elementary grammar is meant knowledge of the paradigms, including the four conjugations of regular verbs, as well as the most frequently used irregular verbs and those belonging to the same classes as *sentir*, *paraître*, *craindre*, etc.; knowledge of elementary syntax, including the place of personal

pronouns when used as direct or indirect objects. This knowledge may be tested as well by translation in French of very simple English sentences as by direct questioning.

The following grammatical nomenclature will be adhered to on the examination papers:—Article: definite, indefinite, and partitive. Noun: common, proper. Adjective: qualifying and determinative, the latter including demonstrative, possessive, numeral, indefinite, and interrogative. Pronoun: personal, demonstrative, possessive, indefinite, relative, and interrogative. Verbs: auxiliary, regular, irregular, and impersonal; active and passive; transitive and intransitive. Adverbs of quantity, time, place, and manner. Prepositions. Conjunctions. Interjections. For the moods and tenses of verbs the following will be adhered to:—Indicative: simple tenses—present, imperfect, future, past definite or preterite; compound tenses—past indefinite, pluperfect, future anterior, past anterior. Subjunctive: simple tenses—present, imperfect; compound tenses—past, pluperfect. Conditional: present, past. Imperative: present, past. Infinitive: present, past. Participle: present, past.

The preparation for the examination, if spread over two years, ought to occupy no less than three weekly recitations of one hour each; good results might be obtained in one year with daily recitations of forty-five minutes each.

The teachers in preparatory schools will greatly help the work of the school if they will bear in mind that definite knowledge is what is required, and not merely acquaintance with the forms of the language. A firm grasp of the most important rules and most constant forms will be found much more useful than the knowledge of some curious exception. Pronunciation, although it cannot be tested at the entrance examination, which is wholly in writing, must not be neglected. Applicants ought to be able to read aloud intelligibly what they are expected to be able to translate.

The use of good English is expected on the part of the candidates on their examination books, whether in answers to direct questions or in translations from French to English.

Only candidates coming for their *full* or *final* entrance examination can present French. It cannot be presented in the *preliminary* examination.

The object of the admission requirement in French is to secure for the students in the professional schools ability to use readily French authorities on the subjects taught in the school. Scientific works in French will have to be read wholly or in part by every student from the first year on.

German:

The elements of German Grammar.

The ability to read easy German, such as Andersen's or Grimm's Märchen.

The object of the entrance examination in German is to determine whether the candidate has a sufficient knowledge of grammar, vocabulary, and idiom, to read easy German prose at sight. Hauff's and Grimm's Märchen are suggested merely to indicate the grade of work; any easy stories or plays can be used in preparation with equally good results.

An adequate preparation for this examination ought to extend over two years, with three recitations a week, at the ordinary pace of school work.

Instruction in grammar should be thorough with regard to the ordinary paradigms and every-day constructions; and the ordinary connective words —auxiliaries, prepositions, conjunctions, etc.—should be learned early and thoroughly. But grammar-drill should, after the first introductory lesson. follow rather than precede abundant practice in reading. Pupils should prepare lessons of suitable length from the text, and be held to strict account, not only for the vocabulary, but also for the grammatical points in the lesson. At least 100 pages should be covered in this careful way in the course of preparation. Besides this kind of work, the pupils should have daily practice in translation at sight, and should read in that way not less than 200 pages.

It is recommended that the required preparation of German as set forth above should be supplemented by the reading of Gore's German Science Reader.

History:

On the equivalent of Johnston's History of the United States.

Freehand Drawing:

Including the ability to sketch, both in outline and with proper shading, ordinary objects, such as a house, a simple piece of machinery, a piece of flat ornament from a copy, a group of geometrical solids. Each applicant must execute the required drawings in the presence of the examining officer. No certificate of drawings made elsewhere is accepted.

7 Entrance examinations will be held at the University, and for the convenience of candidates for admission residing at a distance from New York, at other principal cities, on Wednesday, June 10th, 1896, and days following, and on Monday, September 28th, 1896, and days following, and, by permission of the faculty on suitable application, at any time during the session. In 1897 these examinations will be held on Wednesday, June 9th, and days following, and on Monday, September 27th, and days following.

Examinations for entrance at other cities will be held on June 10th, 1896, and days following, by the following gentlemen:

Belmont, California, by W. T. Reid, A.M., *Head Master of the Belmont School.*

Charleston, South Carolina, by P. E. Chazal, A.B., E.M.

Chicago, Illinois, by E. G. Barratt, C.E.

Cleveland, Ohio, by R. F. Jopling, E.M.

Concord, New Hampshire, by C. S. Knox, A.M.

Denver, Colorado, by T. B. Stearns, E.M.

St. Louis, Missouri, by W. B. Potter, A.M., E.M.

Salt Lake City, Utah, by R. H. Terhune, E.M.

8 The applicant may present himself in a portion of the subjects in June, and complete his examinations in September of the same year. But no examination for admission will be allowed to stand to the credit of an applicant for a period longer than sixteen months.

Preliminary Examinations

9 An applicant duly enrolled, who has filed the required certificate from his principal teacher, may, at the appointed examination time in May or June of the year preceding his admission into the first class, but not at any other time, be examined on certain portions of the foregoing subjects. Such an applicant may offer at the preliminary examination all subjects required for admission *except*

In algebra, equations of the second degree and beyond.
In geometry, solid and spherical geometry.
Trigonometry.
French.
German.
English Composition.

Diplomas and Certificates in Lieu of Examination

10 Diplomas and certificates of colleges and schools of science will be accepted in lieu of examination, *if satisfactory to the examining officers.* Each examining officer decides the question for his special department. No certificates in lieu of examinations will be accepted, except those of degree-granting institutions, including the Regents of the University of the State of New York.

Admission and Conditions

11 The Committee of the Faculty on Admissions and Examinations will decide, and report to the Dean, within twelve days after the conclusion of the examination, which candidates have been admitted, which have been admitted conditionally, and which have been rejected.

12 Students deficient in minor studies may be admitted conditionally; each case being considered on its merits by the Committee on Admissions and Examinations. Students admitted conditionally at the beginning of the academic year must satisfy all conditions within a year or at such time as may be determined by the Committee on Admissions and Examinations. Students who fail to satisfy their entrance conditions within the time specified will be dropped from the roll.

13 The Committee of the Faculty on Admissions and Examinations have jurisdiction over all questions arising under the rules relating to entrance examinations.

Advanced Standing

14 Candidates for advanced standing must pass a satisfactory examination upon the studies stated in Section 6, and also upon those pursued by the class up to the time at which they propose to enter.

15 No candidates are admitted later in the course than the beginning of the fourth year.

Attendance

16 Prompt attendance is required upon all the exercises of the school. Each instance of tardiness will be counted as half an absence.

17 Attendance during all the hours specified on the scheme of attendance adopted by the faculty is obligatory.

18 Any student who shall have been absent from more than ten per cent. of the exercises in any subject, shall not be entitled to examination in that subject.

19 Every student is expected and required to keep an account of his absences, and should he exceed the limit allowed in any course, he must present to the Dean, during the week preceding the stated examination, satisfactory explanation of all his absences, or be debarred from the examination.

20 Any student who, being present at the school, shall absent himself from any exercise, or shall leave the grounds during the hours at which his attendance is due, shall be liable to removal from the roll of his class.

21 Students are required to attend all the exercises and pass all the examinations of the class and course to which they belong unless specially excused by vote of the faculty.

22 By special permission of the faculty, students may attend exercises not required in the class or course to which they belong, provided that such attendance does not interfere with the required exercises of their class and course. Such students are held to the same rules of attendance and examination in the extra studies as in the required studies of their class and course.

23 Students who obtain on examination in advance a mark of *eight* or more in any subject may be excused from attendance upon the exercises in that subject. This rule does not apply to students who repeat the studies of any year under by-law 27. Reports of such standing must be filed with the Dean of the faculty, who alone is authorized to excuse students from attendance.

24 Any student who shall have passed a satisfactory examination in Columbia College in any study forming a part of one of the regular courses in the professional schools, will not be required to pursue that study in the school.

Examinations

25 Examinations will be held at the end of the first term (semi-annual), or at the end of the year (annual), on all subjects taught in the school.

26 Any student found guilty of fraudulent practices at examination will be summarily dismissed from the school.

27 Any student who shall fail to pass in any of his studies at the regular semi-annual or annual examination, may present himself for a second examination at the end of the summer vacation ; failing to pass in this second examination, his name will be dropped from the roll of his class, and he will not be

permitted to attend any of the exercises of said class, except by special permission; but he may enter the succeeding class and pursue all of its exercises and present himself with that class for examination in all subjects; upon failing a third time in any study, his name will be dropped from the roll of the school.

28 Absence from the regular semi-annual or annual examination, unless excused by the faculty, will be counted a failure to pass that examination. This rule shall apply to examinations for delinquents held at the end of the summer vacation.

29 Unless for reasons of weight special examinations will not be granted to students who fail at the regular examinations; but they may present themselves at the time of the next regular examinations.

30 Examinations at times other than here designated are not held except by order of the faculty.

31 Deficient students of the first, second, or third years will not be allowed to attend any summer school without special permission of the faculty.

32 No student is entitled to a degree until he has passed satisfactory examinations in all the studies of the course in which he desires to graduate.

33 When a student fails to receive his degree with his class, and returns at some later period to present himself for examination for the same, he will be required to comply with all the requirements at the later date, and the same rule shall apply to students who have received one degree and make application for another.

Standing

34 Every officer keeps a record of the scholarship of each student.

35 The maximum mark is ten in each department, and six is required to pass a student.

Memoirs and Summer Work

36 During the vacations following the close of each year, memoirs on subjects, which will be assigned, are required of students as follows: of students in the courses of Electrical Engineering, of Analytical and Applied Chemistry, and of Architecture, at the close of each year. The time specified for the completion and handing in of memoirs in chemistry and electrical engineering is November 1st of each year; for other memoirs and summer work the time specified is the second Monday in October.

37 Students of the second, third, and fourth classes who fail to hand in the memoirs, drawings, and other summer work required of them under the rules by a specified time shall not be permitted to hand them in until the beginning of the next academic year, and failing in this latter requirement they shall be dropped from the roll of the class. This requirement may be waived, for reasons of weight, in the case of students of the fourth class.

Special Students

38 Graduates of the School of Mines, the School of Chemistry, the School of Engineering, and the School of Architecture, and of other institutions of like grade and standing, may pursue any subjects taught in the schools for which they are properly qualified.

39 Permission to pursue special courses is sometimes given, for reasons of weight, to persons of mature age who are not graduates, but special students are not desired in the regular professional courses.

The Laboratories and Drawing Academies

40 No student will be allowed in a laboratory or a drawing academy at a time when his attendance there is not due. During hours assigned for practical work in each of the laboratories, and in the drawing academies, the attendance of students will be required. A record of the daily attendance and of the progress of each student will be kept by the officer in charge.

41 The attendance of students of the first and second years in the drawing-room at such times as they are not engaged at lectures, between 9.30 A.M. and 1.30 P.M., is obligatory for students in engineering and architecture, for such hours and times as may be selected by the Professors of Engineering and Architecture.

Order

42 Good order and gentlemanly deportment are required of all students, as a condition of attendance.

43 Smoking is prohibited in the University buildings.

NOTE.—To render unnecessary many inquiries addressed to the Registrar, it is here stated that there are no dormitories attached to the school.

LIBRARY

The library is open to all officers, students, and graduates, for borrowing and reference, daily, except Sundays, Good-Friday, Fourth of July, Thanksgiving day, and Christmas day, throughout the year, including all other holidays and vacations.

It contains about 215,000 volumes, and is rapidly growing. It has full sets of nearly all important journals, transactions, and official reports in mining, metallurgy, geology, chemistry, physics, mathematics, and the other pure and applied sciences. More than 900 serials are regularly received. All important works on mining and allied subjects are usually purchased as they appear.

The architectural library is also accessible to students in the evening.

FEES AND EXPENSES

1 Each student must pay a fee of five dollars ($5) before matriculation on entrance to the school. If an examination for entrance is required such fee must be paid by the applicant for admission before examination; and in case the examination is held at a time not appointed in previous public announcements, the fees required are ten dollars ($10).

In the case of an applicant who completes his examination for admission at the appointed entrance examinations of successive years, but one matriculation fee of five dollars ($5) is required.

2 The annual tuition fee for undergraduate students is two hundred dollars ($200), payable one-half on the first day of each session.

3 To insure the prompt return in good order of reagent bottles, of tools, of keys to lockers, to drawing tables, to laboratory tables, a deposit of ten dollars ($10) is required. Students not making a deposit for apparatus, etc., will deposit one dollar ($1) for each key to a locker or drawing table.

There is a coat-room for those students who do not care to have lockers.

4 Every student admitted to an extra or special examination, in anticipation of the time regularly appointed, or in consequence of failure to attend, or to pass satisfactorily at any entrance, intermediate, or concluding annual examination, or any other regular examination throughout the course, is required to pay a fee of five dollars ($5) before being admitted to such examinations.

5 Every candidate for the degree of Engineer of Mines, or Civil Engineer, or Electrical Engineer, or Metallurgical Engineer, or Bachelor of Science, or Master of Arts, is required to pay a fee of twenty-five dollars ($25) before being admitted to the final examinations.

6 Every candidate for the degree of Doctor of Philosophy is required to pay a fee of thirty-five dollars ($35) before being admitted to the examinations for such degree.

7 The necessary expenses of a student are:

(*a*) Board, including room-rent, fire and light, and washing, a week, from	$6.50 to $10
(*b*) Matriculation fee	5
(*c*) Extra fee, for examinations at unusual times	5
(*d*) Annual tuition fee for undergraduate students	200
(*e*) Deposit to insure return of keys, etc.	10
(*f*) Text-books for the first class, about	15
For the second class, about	30
For the third class, about	25 to 50
For the fourth class, about	20
(*g*) Drawing materials for the first and second classes, each	15 to 25
For each of the other classes	5 to 10
(*h*) Laboratory apparatus for laboratory courses for each of the four years	20 to 60

(*i*) During the vacations at the close of the first, second, and third years, traveling and board for summer class in field surveying for students in the courses of Mining Engineering, Civil Engineering, Sanitary Engineering, and Metallurgy	\$50 to \$75
(*j*) During the vacation at the close of the third year, traveling and board for summer class in practical mining for students in the courses of Mining Engineering and Metallurgy	75 to 100
(*k*) During the vacation at the close of the third year, traveling and board for summer class in practical geodesy for students in the courses of Civil Engineering and Sanitary Engineering	50 to 80
(*l*) During the vacation at the close of the third year, traveling and board for summer class in field geology for students in the course of Mining Engineering . .	15 to 20
(*m*) Candidates for admission to advanced standing, who attend the summer school in surveying . . .	35
(*n*) Candidates for admission to advanced standing, who attend the summer school in practical mining . .	50
(*o*) Graduation fee for undergraduate students (final examination)	25

8 The fees required of GRADUATES and SPECIAL STUDENTS attending the school, but *not candidates for a degree*, are as follows :

(*a*) Matriculation fee	\$5
(*b*) Extra fee, for examinations at unusual times . .	5
(*c*) Full fee entitling the student to all the privileges of the school, per annum	150
(*d*) For the use of the cabinets	25
(*e*) For attendance in lecture-room and other special instruction, per annum for each hour a week of such instruction	15
(*f*) For the use of the drawing academy	25
(*g*) For the use of the laboratories, or either of them . .	50
(*h*) For special students in the university courses in Architecture, for each period of two months (*in advance*) .	30

Should the amount of fees, exclusive of the matriculation fee, payable by any student, not exceed \$100, the entire amount is payable at the beginning of the academic year, or at the matriculation of the student. Should the amount exceed \$100, payment is required in two equal instalments, one at the beginning of each session of the academic year.

GRADUATES who are *candidates for degrees* must pay the matriculation fee of \$5 and an annual tuition fee of \$150, irrespective of the number of hours of weekly attendance, for the degree of Master of Arts and the degree of Doctor of Philosophy ; for other degrees, \$200, and for examination,

For degree of Doctor of Philosophy	\$35
For other degrees	25

Apparatus Supplies

1 Students may purchase apparatus of any of the dealers in the city.

2 To avoid inconvenience and expense to the students, and to secure a proper selection, the school undertakes, at considerable trouble and expense, to lend apparatus on the following conditions :

(*a*) Each student engaged in laboratory work, who draws apparatus from the school, must make a deposit of forty dollars ($40) with the Registrar, which deposit will be credited to him on the ledger. In case of excessive draughts of apparatus an additional deposit may be required.

(*b*) Each student shall be entitled, on presenting his receipt at the apparatus-room, to draw the regular set of apparatus for qualitative analysis, for quantitative analysis, for organic analysis, for assaying, for microscopy, or for bacteriology, on account of his deposit, and from time to time to obtain ordinary articles that he may need, which will be charged to him. At the end of the year he will be credited with those articles which he returns in good order, and the value of those which he has injured or broken will be deducted from his deposit.

(*c*) The apparatus-room will be open for issuing apparatus every day at convenient hours.

(*d*) No charge is made for ordinary chemicals.

Free Tuition

Free tuition may be granted by the faculty in special cases, on the ground of character, ability and need combined, but the total number of students receiving free tuition shall not exceed ten per cent. of the total number of students registered. Free tuition cannot be granted to any student during the first year of his connection with the College.

Fellows shall be exempt from the payment of all fees.

Free students shall not be exempt from the payment of fees for matriculation, for extra examination, and for examination for a degree.

Committee on Aid for Students

The University Council has constituted a Standing Committee on Aid for Students, consisting at present of the following members :

Professor J. F. Kemp (Faculty of Pure Science), Chairman.
" T. S. Fiske (Columbia College).
" G. S. Huntington (Faculty of Medicine).
" F. M. Burdick (Faculty of Law).
" F. R. Hutton (Faculty of Applied Science).
" F. H. Giddings (Faculty of Political Science).
" H. A. Todd (Faculty of Philosophy).

It is the design of the Committee to put students desiring to work their way through college, especially those coming from elsewhere than New York or the immediate vicinity, in the way of earning enough for their partial or com-

plete support, or if possible to extend assistance to them in other ways, while they are pursuing their studies here. It is believed that many opportunities may be offered to students of this class if the fact of their desire to obtain employment is made known. Some of the openings likely to be available are: private tutoring, translating, copying of various sorts, teaching in evening schools, traveling companions, stenography and typewriting. All communications should be addressed to the Committee.

FELLOWSHIPS, SCHOLARSHIPS, AND OTHER PROVISION FOR THE ASSISTANCE OF STUDENTS

University Fellowships

Twenty-four fellowships, known as "University Fellowships," each of the value of five hundred dollars a year, are awarded by the Council to those applicants who give evidence of special fitness to pursue courses of higher study and original investigation, the competition to be open to graduates of all colleges and scientific schools. Vacancies occurring in any of such fellowships shall be filled in the same manner in which original appointments are made.

The application shall be made prior to March 1st, in writing, addressed to the President of Columbia University. Applications received later than March 1st may fail of consideration. The term of the fellowship is one year, dating from July 1st. Residence should begin October 1st.

The candidate must give evidence

(*a*) of a liberal education, such as a diploma already granted, or about to be received, from a college or scientific school of good repute;

(*b*) of decided fitness for a special line of study, such as an example of some scientific or literary work already performed;

(*c*) of upright character, such as a testimonial from some instructor.

The value of each fellowship is five hundred dollars. Payments will be based on the time during which the Fellow shall have been in residence. The holder of a fellowship is exempt from the charges for tuition.

Every holder of a fellowship will be expected to perform such duties as may be allotted to him in connection with his course of study, which course shall be such as to lead to the degree of Doctor of Philosophy. He will be expected to devote his time to the prosecution of special studies under the direction of the head of the department to which he belongs, and before the close of the academic year to give evidence of progress by the preparation of a thesis, the completion of a research, the delivery of a lecture, or by some other method. He must reside in New York or vicinity during the academic year.

No holder of a fellowship shall be permitted to pursue a professional or technical course of study during his term. With the written approval of the President, but not otherwise, he may give instruction or assistance in any department of the University.

A Fellow may be reappointed at the end of a year for reasons of weight. No Fellow may be reappointed for more than two terms of one year each.

As these fellowships are awarded as honors, those who are disposed, for the benefit of others or for any other reason, to waive the pecuniary emoluments, may do so, and still have their names retained on the list of Fellows.

FELLOWSHIPS

Tyndall Fellowship

A fellowship known as the "John Tyndall Fellowship for the Encouragement of Research in Physics" is held by some suitable person, who is either a graduate of or a student in the University, but not necessarily a candidate for a degree. Such Fellow shall be appointed by the Council upon a recommendation of the head of the department of Physics. Such appointment shall always be for the term of one year only, but the Fellow, for the time being, shall be eligible for appointment from year to year, upon like recommendation. The Fellow so appointed shall be entitled to receive during his term of office the net income of the capital sum constituting the endowment, to be paid in four equal instalments on the usual quarter days, upon the certificate of the President; and the Trustees guarantee that such net income will amount to at least six hundred and forty-eight dollars a year, being six per cent. upon ten thousand eight hundred dollars, the fund presented to the University by Professor Tyndall.

Barnard Fellowship

A fellowship known as the "Barnard Fellowship for Encouraging Scientific Research" is held by a graduate of Columbia College or of one of the schools under the Faculty of Applied Science who has evinced decided aptness for physical investigation and who may be disposed to devote himself to such investigation for some years continuously. Such Fellow shall be appointed by the Council upon the joint recommendation of the Faculty of Columbia College and the Faculty of Applied Science. Such appointment shall be for the term of one year only, but the Fellow, for the time being, shall be eligible to reappointment from year to year upon like joint recommendation. The Fellow so appointed shall be entitled to receive during his term of office the net income of the capital sum constituting the endowment, to be paid to him in four equal instalments on the usual quarter days, upon the certificate of the President.

Duties of Tyndall and Barnard Fellows

It shall be the duty of a "John Tyndall" or "Barnard" Fellow to devote himself faithfully to the investigation of some subject in physical science at this University, or at some other in this country or abroad, under the supervision of some known physicist approved by the President and the head of the de-

partment of Physics. He shall make a report quarterly to the President, giving an account of the work in which he has been engaged during the three months preceding; which report shall be certified by the physicist superintending and directing him. In case of failure faithfully to fulfil the obligations imposed upon him, such Fellow shall forfeit all privileges and emoluments conferred upon him by his appointment to the fellowship, and the Council may at any time declare the fellowship to be vacant.

Columbia Fellowship

A fellowship known as the "Columbia Fellowship in Architecture," which shall be open to all graduates of the department of Architecture less than thirty years of age, is awarded under such rules and regulations as shall from time to time be determined by the President and the Professor of Architecture. Holders of such fellowship shall devote the income thereof to foreign study and travel in accordance with plans prepared by themselves and approved by the President and such professors, and shall upon return present a written report and exhibit drawings in the department of Architecture. Said fellowship shall be awarded in the spring of every even-numbered year, and payments thereof shall be made by the Treasurer, on the certificate of the Professor of Architecture, endorsed by the President, in four equal instalments of three hundred and twenty-five dollars each on the usual quarter days.

McKim Fellowship

A fellowship, known as the "McKim Fellowship in Architecture," is awarded upon like conditions and for like purposes as are specified in the foregoing section, but such fellowship shall be awarded in the spring of every uneven-numbered year, and payments thereof shall be made by the Treasurer, on the certificate of the Professor of Architecture, endorsed by the President, in eight equal instalments of two hundred and fifty dollars each on the usual quarter days. The holder of this fellowship shall remain abroad two years, ten months of which he shall spend as a student of the *American School of Architecture in Rome.*

FELLOWSHIP REGULATIONS

No Fellow shall be allowed to accept remunerative employment except by permission of the President, and the acceptance of any such employment, without such permission, shall operate to vacate the fellowship.

All Fellows, except as hereinbefore provided, shall be required to pursue their studies during the term of their fellowship at the University, unless permission be granted them by the President to study elsewhere.

All Fellows shall be governed by such rules and regulations, not inconsistent with the Statutes, as may be prescribed by the Council.

PRIVILEGES OPEN TO COLUMBIA STUDENTS IN OTHER INSTITUTIONS

The American Museum of Natural History places its collections at the service of advanced students of Columbia University for the purposes of study and research, and provides them with the necessary facilities for work.

The Metropolitan Museum of Art admits students of Columbia University to the Museum on presentation of their matriculation cards, and gives them permission to draw, sketch, or copy objects in the Museum, the curator of the department in which the student desires to work furnishing him with cards for the work.

Objects may be removed temporarily from exhibition for the purpose of special study, and students are allowed to study these objects in rooms specified for the purpose.

CALENDAR

1896—June 10—Examinations for admission begin, Wednesday.
June 15—Examinations for admission end, Monday.
Sept. 28—Examinations for admission begin, Monday.
Oct. 5—First term, 143d year begins, Monday.
Nov. 3—Election day, Tuesday, holiday.
Nov. 26—Thanksgiving day, Thursday, holiday.
Dec. 21—Christmas holidays begin, Monday.
1897—Jan. 2—Christmas holidays end, Saturday.
Jan. 25—Mid-year examinations begin, Monday.
Feb. 6—First term ends, Saturday.
Feb. 8—Second term begins, Monday.
Feb. 12—Lincoln's birthday, Friday, holiday.
Feb. 22—Washington's birthday, Monday, holiday.
Mar. 3—Ash-Wednesday, holiday.
April 16—Good-Friday, holiday.
May 17—Concluding examinations begin, Monday.
May 30—Memorial day, Sunday.
May 31—Monday, holiday.
June 9—Commencement, Wednesday.
June 9—Examinations for admission begin, Wednesday.
June 12—Examinations for admission end, Saturday.
Sept. 27—Examinations for admission begin, Monday.
Oct. 4—First term, 144th year begins, Monday.

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Columbia University in the City of New York

SCHOOL OF MINES
SCHOOL OF CHEMISTRY
SCHOOL OF ENGINEERING
SCHOOL OF ARCHITECTURE

GENERAL INFORMATION

1897–98

NOTE

Columbia University offers the following courses:

In Columbia College:				
A four-years' course leading to the degree of				A.B.
In the School of Law:				
A three-years' course leading to the degree of				LL.B.
In the School of Medicine (College of Physicians and Surgeons):				
A four-years' course leading to the degree of				M.D.
In the School of Mines:				
A four-years' course in	Mining Engineering	leading to	the degree of	E.M.
" "	Metallurgy	"	"	Met.E.
In the School of Chemistry:				
A four-years' course in	Analytical Chemistry	leading to	the degree of	B.S.
" "	Industrial Chemistry	"	"	B.S.
" "	Organic Chemistry	"	"	B.S.
In the School of Engineering:				
A four-years' course in	Civil Engineering	leading to	the degree of	C.E.
" "	Sanitary Engineering	"	"	C.E.
" "	Electrical Engineering	"	"	E.E.
" "	Mechanical Engineering	"	"	Mech.E.
In the School of Architecture:				
A four-years' course in	Architecture	leading to	the degree of	B.S.

Also many courses under the various faculties, especially the Faculties of Philosophy, Political Science, Pure Science, and Applied Science, leading to the university degrees of Master of Arts and Doctor of Philosophy. A combination of courses under the Faculties of Law and Political Science leads to the degree of Master of Laws.

The first-year courses of the School of Law, the School of Medicine, the School of Mines, the School of Chemistry, the School of Engineering, and the School of Architecture, are open, as electives, to Seniors in the College. Consequently such Seniors who have joined the College not later than the beginning of their Junior year can prepare themselves for advanced standing in these schools by electing these first-year courses and counting them for the degree of Bachelor of Arts.

Information and circulars as to any of the above courses may be had by addressing the Secretary of the University.

The catalogue of the University is published in December, and is sold at twenty-five cents a copy.

It is expected that the work in all the schools and departments of the University, except in the School of Medicine, which will remain at its present location, 10th Avenue and 59th Street, will be begun in October, 1897, upon the new site, 116th Street and Amsterdam Avenue, Morningside Heights.

may 10–97–10000

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SCHOOL OF MINES
SCHOOL OF CHEMISTRY
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UNDER THE DIRECTION OF THE FACULTY OF APPLIED SCIENCE

The following departments are represented in the faculty:

ARCHITECTURE
ASTRONOMY
CHEMISTRY
CIVIL ENGINEERING
ELECTRICAL ENGINEERING
MECHANICAL ENGINEERING
SANITARY ENGINEERING
GEOLOGY
MATHEMATICS
MECHANICS
METALLURGY
MINERALOGY
MINING
PHYSICS

PRESIDENT

SETH LOW, LL.D.

Officers of the Faculty in the University Council

HENRY S. MUNROE, E.M., Ph.D.
(Dean, Faculty of Applied Science) ex-officio Member

FREDERICK R. HUTTON, C.E., Ph.D. . . . . *Elected Delegate*

Standing Committees

COMMITTEE ON ADMISSIONS AND EXAMINATIONS: Professors Munroe, Van Amringe, Hutton, Hamlin, Kemp

COMMITTEE ON SPECIAL STUDENTS: Professors Munroe, Hutton, Hamlin

OFFICERS OF INSTRUCTION

Professors

CHARLES F. CHANDLER, Ph.D., M.D., LL.D., *Professor of Chemistry*
J. HOWARD VAN AMRINGE, Ph.D., L.H.D., *Professor of Mathematics*
OGDEN N. ROOD, A.M., *Professor of Physics*
HENRY S. MUNROE, E.M., Ph.D., *Professor of Mining, and Dean of the Faculty*
WILLIAM R. WARE, B.S., *Professor of Architecture*
FREDERICK R. HUTTON, C.E., Ph.D., *Professor of Mechanical Engineering*
JOHN KROM REES, E.M., Ph.D., *Professor of Astronomy, and Director of the Observatory*
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CHARLES E. COLBY, E.M., C.E., *Adjunct Professor of Organic Chemistry*
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FRANK DEMPSTER SHERMAN, Ph.B., *Adjunct Professor of Architecture*
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WILLIAM HALLOCK, Ph.D., *Adjunct Professor of Physics*
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CHARLES E. PELLEW, E.M., *Adjunct Professor of Chemistry*

Emeritus Officers

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NATHANIEL L. BRITTON, E.M., Ph.D., *Emeritus Professor of Botany*

Instructors

JAMES S. C. WELLS, Ph.D., *Instructor in Analytical Chemistry (Qualitative Analysis)*
ALEXIS A. JULIEN, Ph.D., *Instructor in Geology and Curator*
FERDINAND G. WIECHMANN, Ph.D., *Instructor in Chemical Philosophy and Chemical Physics*
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Reginald Gordon, A.B., *Instructor in Physics*
Edmund H. Miller, Ph.D., *Instructor in Analytical Chemistry and Assaying*

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Louis H. Laudy, Ph.D., *Tutor in General Chemistry*
Joseph Struthers, Ph.D., *Tutor in Metallurgy*
Joseph C. Pfister, A.M., *Tutor in Mechanics*
Lea McI. Luquer, C.E., Ph.D., *Tutor in Mineralogy*
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Assistants

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Henry S. Curtis, A.B., *Assistant in Physics*
Herbert T. Wade, A.B., *Assistant in Physics*
Luther E. Gregory, C.E., *Assistant in Mechanical Engineering*
Parker C. McIlhiney, Ph.D., *Assistant in Metallurgy*
Thomas H. Harrington, C.E., *Assistant in Mechanical Engineering*
Henry E. Keyes, Ph.D., *Assistant in Physics*
Theodore Greely White, Ph.B., A.M., *Assistant in Physics*
Charles Derleth, Jr., B.S., C.E., *Assistant in Civil Engineering*
Dana C. Wells, A.B., E.E., *Assistant in Physics*
John Alexander Mathews, M.S., A.M., *Assistant in Assaying*
Heinrich Ries, Ph.D., *Assistant in Mineralogy*
Frank C. Hooper, Met.E., *Assistant in Mining*
Charles H. Fulton, *Assistant in Analytical Chemistry*
Edwin C. Holden, E.M., *Assistant in Analytical Chemistry*
Henry Clapp Sherman, A.M., *Assistant in Analytical Chemistry*
Samuel G. F. Townsend, A.B., E.E., *Assistant in Electrical Engineering*
William C. Uhlig, Ph.B., *Assistant in Analytical Chemistry*

Curators

Maximilian K. Kress, A.M., *Curator and Lecturer in Architecture*
Gilbert van Ingen, *Curator of the Geological Collections*

Offices of Administration of the University

George H. Baker, A.M., *Librarian*
William H. H. Beebe, *Secretary*
George F. Fisher, *Bursar*

COURSES OF STUDY

Columbia University offers opportunity for the study of science in several faculties and schools, namely:

1 In Columbia College, the undergraduate department of the University.

2 In the School of Mines, the School of Chemistry, the School of Engineering, and the School of Architecture, which are professional schools under the charge of the Faculty of Applied Science.

3 In the university courses conducted by the Faculty of Applied Science, and by the Faculty of Pure Science.

Collegiate Preparation Recommended

Candidates intending to enter the School of Mines, the School of Chemistry, the School of Engineering, or the School of Architecture, are recommended to take advantage of the opportunities offered in Columbia College, the undergraduate department of the University, under the new curriculum, which goes into effect in 1897. By a proper choice of studies under this curriculum, students, at the end of four years, will obtain the degree of Bachelor of Arts, and can at the same time prepare themselves to enter the third year of either of the professional schools, and take their technical degrees two years later. As students may and do enter the College two years earlier than they enter the professional schools, they will be able by taking this combined course of study to obtain the professional degree at the same age as though they entered the professional school in the first instance at the present average age. This combined six-year course is strongly urged and recommended, for the reason that engineers, chemists, and architects, as professional men, need the liberal training offered by a collegiate course quite as much as do lawyers, physicians, or clergymen. Experience has shown that those who have taken a liberal course of study in the past, and who have enjoyed the advantages of such an education before beginning their technical studies, have taken a much higher standing in their profession, have exercised greater influence in the community, and have been much more useful men, than those who have relied upon a purely scientific or professional course of study.

Without sacrificing the necessary elements of a liberal education, the widest opportunity for elective work in science is offered in this new curriculum which will permit the student to pursue almost any desired line of study, and to specialize in it to almost any desired extent. A properly chosen course of study in the College will thus fit students for advanced work and original investigation, and is to be recommended to candidates for higher degrees under the Faculty of Applied Science or the Faculty of Pure Science.

Details of the courses of study to be offered will be found in the Columbia College circular, which will be sent on application to the Secretary of the University.

Regular Professional Courses

The Faculty of Applied Science has charge of the following schools:

1 The SCHOOL OF MINES, with four-years' courses leading to the degrees of Engineer of Mines and Metallurgical Engineer.

2 The SCHOOL OF CHEMISTRY, with four-years' courses in Analytical, Industrial, and Organic Chemistry, leading to the degree of Bachelor of Science.

3 The SCHOOL OF ENGINEERING, with four-years' courses in Civil Engineering, Sanitary Engineering, Electrical Engineering, and Mechanical Engineering, the first two leading to the degree of Civil Engineer, and the others to the degrees of Electrical Engineer and Mechanical Engineer respectively.

4 The SCHOOL OF ARCHITECTURE, with a four-years' course leading to the degree of Bachelor of Science.

These courses are intended to meet the requirements of the several professions indicated. Many of the courses permit a certain amount of specialization, particularly in the fourth year. The courses in the School of Mines are so arranged that the student can emphasize the engineering, the metallurgical, or the geological side of his profession, while one of the alternative courses in Mechanical Engineering is designed for those who wish to make a specialty of mine plant and machinery. A course in Sanitary Engineering (leading to the degree of Civil Engineer) is provided for those who wish to emphasize this important branch of civil engineering. The Mechanical Engineering course offers three alternatives in the fourth year, emphasizing respectively the dynamic, the electrical, and the mining side of the mechanical engineer's work. Three courses are offered in Chemistry, for Analytical Chemists, Industrial Chemists, and Organic Chemists respectively. The School of Architecture offers two alternatives in the fourth year—a course of Advanced Architectural History and Design, and a course of Advanced Architectural Engineering and Practice. Full particulars regarding each of these courses of study are contained in special circulars, which will be forwarded on application to the Secretary of the University.

University Courses in Applied Science

The Faculty of Applied Science has charge of candidates for the degrees of Master of Arts and Doctor of Philosophy who desire to undertake advanced study or special investigations in mining, metallurgy, engineering (civil, sanitary, electrical, and mechanical), or in architecture. A circular containing information as to these higher degrees may be obtained on application to the Secretary of the University.

University Courses in Pure Science

The Faculty of Pure Science has charge of all advanced work leading to the degrees of Master of Arts and Doctor of Philosophy in the physical sciences (chemistry, physics, and chemical physics); in the mathematical sciences (pure mathematics, mechanics, mathematical physics, astronomy, and geodesy); and in the natural sciences (mineralogy, lithology, geology, botany, zoölogy, palæontology, and physiology). A circular giving details of these courses may be obtained on application to the Secretary of the University.

BY-LAWS

1 At the beginning of the first year each student must elect which of the several courses he intends to pursue, and must thenceforth abide by his election unless permitted by the Committee on Admissions and Examinations to make a change.

2 No student is allowed to pursue more than one course at a time.

Admission

3 Candidates for admission to the first class, at its formation, must be of the age of *eighteen years*, complete ; and for admission to advanced standing there will be required a corresponding increase of age ; but this rule may be modified when, in the opinion of the Committee on Admissions and Examinations, there are sufficient reasons to justify its relaxation.

Enrolment and Certificates

4 An applicant for admission must file with the Bursar, at least one week before the day fixed for the entrance examinations, a certificate from his principal instructor containing a definite statement of the subjects which he is qualified to offer for examination.

No student will be examined in June, 1897, whose name is not enrolled and whose certificate is not filed on or before Wednesday, June 2d, of the same year ; nor will any student be examined in September, 1897, whose name is not enrolled and whose certificate is not filed on or before Monday, September 20th. No student will be examined in June, 1898, whose name is not enrolled and whose certificate is not filed on or before Wednesday, June 1st, of the same year ; nor will any student be examined in September, 1898, whose name is not enrolled and whose certificate is not filed on or before Monday, September 19th.

Blank forms of the certificate required can be had upon application to the Bursar. In the case of students expecting to be examined at a distance, the names must be enrolled and the certificates filed one week earlier.

5 Every candidate must, before admission, present a certificate of good moral character from his last teacher, or from some citizen in good standing, and students from other institutions must bring certificates of honorable dismission.

Entrance Examinations

6 Candidates for the first class must pass satisfactory examinations in :

Mathematics :

Arithmetic : greatest common divisor and least common multiple, common and decimal fractions, percentage, interest, square root, and the metric and other ordinary systems of weights and measures. Special importance is attached to accuracy and facility in calculation.

Alegbra (*a*) : factors, common divisors and multiples, fractions, equations of the first degree, with one or more unknown quantities, involution, evo-

lution, the doctrine of exponents, radicals, radical equations reducible to equations of the first degree, and putting problems into equations.

Algebra (*b*): quadratic equations, and such equations with one or more unknown quantities as can be solved by the methods of quadratic equations, ratio and proportion, arithmetical and geometrical progressions, the binomial theorem for positive entire exponents, and the principle of undetermined coefficients including its application to series and partial fractions.

Geometry (*a*): plane geometry, including the solution of simple original exercises and numerical problems.

Geometry (*b*): solid and spherical geometry, including the solution of simple original exercises and numerical problems.

Plane trigonometry: the elementary principles of logarithms, the use of tables of logarithms of numbers and of logarithms of trigonometric functions, and the solution of right-angled and of oblique-angled plane triangles.

Physics:

On the equivalent of Ganot's smaller treatise (Peck's Ganot's Natural Philosophy).

In 1898 and succeeding years candidates will be examined in accordance with the following requirements:

The equivalent of Hall and Bergen's text-book of physics;

An approved laboratory course of at least forty experiments, actually performed at school by the candidate.

Chemistry:

On the non-metallic elements and their important compounds with each other, as given in the ordinary high-school text-books.

In 1898 and succeeding years candidates will be examined in accordance with the following requirements:

The non-metallic elements and their important compounds with each other as usually given in high school text-books.

An approved laboratory course of at least forty experiments actually performed at school, by the candidate, as given in Remsen's, or Armstrong and Norton's Laboratory Manuals.

English:

No applicant will be accepted in English whose work is notably defective in point of spelling, grammar, idiom, punctuation, or division into paragraphs.

1 READING AND COMPOSITION—The candidate will be required to present evidence of a general knowledge of the subject-matter of the prescribed books, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics, to be chosen by the candidate from a considerable number—perhaps ten or fifteen—set before him in the examination paper. The treatment of these topics is designed to show the candidate's power of clear and accurate expression, and will call for only a general knowledge of the substance of the books. In the place of a part or the whole of this test, the candidate may present an

exercise book, properly certified by his instructor, containing compositions or other written work done in connection with the reading of the books.

The candidate is expected to read intelligently all the books prescribed. He should read them as he reads other books ; he is not expected to know them minutely, but to have freshly in mind their most important parts.

The books selected for this part of the examination will be :

1897 : Shakspere's As You Like It ; Defoe's History of the Plague in London ; Irving's Tales of a Traveller ; Hawthorne's Twice Told Tales ; Longfellow's Evangeline ; George Eliot's Silas Marner.

1898 : Milton's Paradise Lost, Books I and II ; Pope's Iliad, Books I and XXII ; The Sir Roger de Coverley Papers in the Spectator ; Goldsmith's Vicar of Wakefield ; Coleridge's Ancient Mariner ; Southey's Life of Nelson ; Carlyle's Essay on Burns ; Lowell's Vision of Sir Launfal ; Hawthorne's House of the Seven Gables.

1899 : Dryden's Palamon and Arcite ; Pope's Iliad, Books I, VI, XXII, and XXIV ; The Sir Roger de Coverley Papers in the Spectator ; Goldsmith's Vicar of Wakefield ; Coleridge's Ancient Mariner ; De Quincey's Flight of a Tartar Tribe ; Cooper's Last of the Mohicans ; Lowell's Vision of Sir Launfal ; Hawthorne's House of the Seven Gables.

2 Study and Composition—This part of the examination presupposes the thorough study of each of the works named below. The examination will be upon subject-matter, literary form, and grammatical and logical structure.

In connection with the reading and study of the required books, parallel or subsidiary reading should be encouraged, and a considerable amount of English poetry should be committed to memory. The essentials of English grammar should not be neglected in preparatory study.

The books selected for this part of the examination will be :

1897 : Shakspere's Merchant of Venice ; Burke's Speech on Conciliation with America ; Scott's Marmion ; Macaulay's Life of Samuel Johnson.

1898 : Shakspere's Macbeth ; Burke's Speech on Conciliation with America ; De Quincey's Flight of a Tartar Tribe ; Tennyson's Princess.

1899 : Shakspere's Macbeth ; Milton's Paradise Lost, Books I and II ; Burke's Speech on Conciliation with America ; Carlyle's Essay on Burns.

French :

The elements of French grammar.

The ability to read easy French, such as Rambaud's Petite Histoire de la Civilisation Française.

The admission examination in French is divided into two parts designed to test respectively (1st), the ability of the applicant to read at sight French prose of ordinary difficulty ; (2d), his knowledge of elementary grammar.

The ability to read ordinary French prose will be acquired, it is believed, by the reading, in addition to the study of Grammar, of three hundred or more 12mo pages of French. It is recommended that the reading be divided between historical narrative and popular works on science, including the names of most of the articles in daily use ; a few very simple descriptive passages may also be included. Although no work is prescribed, the attention of teachers in pre-

paratory schools is called to Alfred Rambaud's Petite Histoire de la Civilisation Française (Paris, A. Colin), and Louis Figuier's Les Grandes Inventions (Paris, Hachette).

By knowledge of elementary grammar is meant knowledge of the paradigms, including the four conjugations of regular verbs, as well as the most frequently used irregular verbs and those belonging to the same classes as *sentir*, *paraître*, *craindre*, etc. ; knowledge of elementary syntax, including the place of personal pronouns when used as direct or indirect objects. This knowledge may be tested as well by translation in French of very simple English sentences as by direct questioning.

The following grammatical nomenclature will be adhered to on the examination papers :—Article : definite, indefinite, and partitive. Noun : common, proper. Adjective : qualifying and determinative, the latter including demonstrative, possessive, numeral, indefinite, and interrogative. Pronoun : personal, demonstrative, possessive, indefinite, relative, and interrogative. Verbs : auxiliary, regular, irregular, and impersonal ; active and passive ; transitive and intransitive. Adverbs of quantity, time, place, and manner. Prepositions. Conjunctions. Interjections. For the moods and tenses of verbs the following will be adhered to : Indicative : simple tenses—present, imperfect, future, past definite or preterite ; compound tenses—past indefinite, pluperfect, future anterior, past anterior. Subjunctive : simple tenses—present, imperfect ; compound tenses—past, pluperfect. Conditional : present, past. Imperative : present, past. Infinitive : present, past. Participle : present, past.

The preparation for the examination, if spread over two years, ought to occupy no less than three weekly recitations of one hour each ; good results might be obtained in one year with daily recitations of forty-five minutes each.

The teachers in preparatory schools will greatly assist in the work if they will bear in mind that definite knowledge is what is required, and not merely acquaintance with the forms of the language. A firm grasp of the most important rules and most constant forms will be found much more useful than the knowledge of some curious exception. Pronunciation, although it cannot be tested at the entrance examination, which is wholly in writing, must not be neglected. Applicants ought to be able to read aloud intelligibly what they are expected to be able to translate.

The use of good English is expected on the part of the candidates in their examination books, whether in answers to direct questions or in translations from French to English.

Only candidates coming for their *full* or *final* entrance examination can present French. It cannot be presented in the *preliminary* examination.

The object of the admission requirement in French is to secure for the students in the professional schools ability to use readily French authorities on the subjects taught in the schools. Scientific works in French will have to be read wholly or in part by every student from the first year on.

German :

The elements of German Grammar.

The ability to read easy German, such as Andersen's or Grimm's Märchen.

The object of the entrance examination in German is to determine whether the candidate has a sufficient knowledge of grammar, vocabulary, and idiom, to read easy German prose at sight. Hauff's and Grimm s Märchen are suggested merely to indicate the grade of work ; any easy stories or plays can be used in preparation with equally good results.

An adequate preparation for this examination ought to extend over two years, with three recitations a week, at the ordinary pace of school work.

Instruction in grammar should be thorough with regard to the ordinary paradigms and every-day constructions ; and the ordinary connective words —auxiliaries, prepositions, conjunctions, etc.—should be learned early and thoroughly. But grammar-drill should, after the first introductory lesson, follow rather than precede abundant practice in reading. Pupils should prepare lessons of suitable length from the text, and be held to strict account, not only for the vocabulary, but also for the grammatical points in the lesson. At least 100 pages should be covered in this careful way in the course of preparation. Besides this kind of work, the pupils should have daily practice in translation at sight, and should read in that way not less than 200 pages.

It is recommended that the required preparation of German as set forth above should be supplemented by the reading of Gore's German Science Reader.

History :

On the equivalent of Johnston's History of the United States.

Freehand Drawing : For candidates for admission to the School of Architecture.

The ability to draw correctly any simple geometrical figure from dictation, and to enlarge or reduce from a copy in outline, an anthemion, an acanthus leaf, a design of iron scroll-work, or some similar ornament. For this work correct construction and accuracy of proportion are more important than fineness of execution.

Out of town examiners are requested to apply to the School of Architecture for examples of the sort of drawings that are required.

Freehand Drawing : For candidates for admission to the other schools.

The ability to sketch, both in outline and with proper shading, ordinary objects, such as a house, a simple piece of machinery, a piece of flat ornament from a copy, a group of geometrical solids.

Each applicant must execute the required drawings in the presence of the examining officer. No certificate of drawings made elsewhere will be accepted.

7 Entrance examinations will be held at the University, and for the convenience of candidates for admission residing at a distance from New York, at other principal cities, on Wednesday, June 9th, 1897, and days following, and on Monday, September 27th, 1897, and days following. By permission of the Committee on Admissions and Examinations, on suitable application, entrance examinations may be held at any time during the session.

Examinations for entrance at other cities will be held in June by the following gentlemen :

Belmont, California, by W. T. Reid, A.M., *Head Master of the Belmont School.*

Bozeman, Montana, by F. W. Traphagen, Ph. D., F. C. S.

Charleston, South Carolina, by P. E. Chazal, A.B., E.M.

Chicago, Illinois, by E. G. Barratt, C.E.

Cleveland, Ohio, by R. F. Jopling, E.M.

Concord, New Hampshire, by C. S. Knox, A.M.

Denver, Colorado, by T. B. Stearns, E.M.

St. Louis, Missouri, by W. B. Potter, A.M., E.M.

Salt Lake City, Utah, by R. H. Terhune, E.M.

8 The applicant may present himself in a portion of the subjects in June, and complete his examinations in September of the same year. But no examination for admission will be allowed to stand to the credit of an applicant for a period longer than sixteen months.

Preliminary Examinations

9 An applicant duly enrolled, who has filed the required certificate from his principal teacher, may, at the appointed examination time in May or June of the year preceding his admission into the first class, but not at any other time, be examined on certain portions of the foregoing subjects. Such an applicant may offer at the preliminary examination the following subjects:

Arithmetic.
Algebra (*a*).
Geometry (*a*).
Physics.
Chemistry.
English, Reading and Composition.
History.
Freehand Drawing.

The following subjects may not be offered at the preliminary examination:

Algebra (*b*).
Geometry (*b*).
Trigonometry.
French.
German.
English, Study and Composition.

Diplomas and Certificates in Lieu of Examination

10 Diplomas and certificates of colleges and schools of science will be accepted, for the ground they cover, in lieu of examination, *if satisfactory to the examining officers.* Each examining officer decides the question for his special department. No certificates in lieu of examinations will be accepted, except those of degree-granting institutions, including the Regents of the University of the State of New York.

Admission and Conditions

11 The Committee on Admissions and Examinations will decide, and report to the Dean, within twelve days after the conclusion of the examinations, those candidates who have been admitted, those who have been admitted conditionally, and those who have been rejected.

12 Students deficient in minor studies may be admitted conditionally ; each case being considered on its merits by the Committee on Admissions and Examinations. Students admitted conditionally at the beginning of the academic year must satisfy all conditions in Mathematics within three months, and other conditions within a year or at such time as may be determined by the Committee on Admissions and Examinations. Students who fail to satisfy their entrance conditions within the time specified may be dropped from the roll.

13 The Committee on Admissions and Examinations have jurisdiction over all questions arising under the rules relating to entrance examinations.

Advanced Standing

14 Candidates for advanced standing must pass satisfactory examinations upon the studies stated in Section 6, and also upon those pursued by the class up to the time at which they propose to enter.

15 No candidates are admitted later in the course than the beginning of the fourth year.

Attendance

16 Prompt attendance is required upon all exercises. Each instance of tardiness will be counted as half an absence.

17 Attendance during all the hours specified on the scheme of attendance adopted by the faculty is obligatory.

18 Any student who shall have been absent for more than ten per cent. of the exercises in any subject, shall not be entitled to examination in that subject.

19 Every student is expected and required to keep an account of his absences, and should he exceed the limit allowed in any course, he must present to the Dean, during the week preceding the stated examination, satisfactory explanation of all his absences, or be debarred from the examination, but he may present himself at the examination in the fall for debarred and deficient students. If the absences are excessive the Committee on Admissions and Examinations may make such further ruling in regard to his examination as may seem to them to be required in his case.

20 Any student who, being present on the grounds, shall absent himself from any exercise, or shall leave the grounds during the hours at which his attendance is due, shall be liable to removal from the roll of his class.

21 Students are required to attend all the exercises and pass all the examinations of the class and course to which they belong unless specially excused by the Committee on Admissions and Examinations.

22 By special permission of the Committee on Admissions and Examinations, students may attend exercises not required in the class or course to which they belong, provided that such attendance does not interfere with the required exercises of their class and course. Such students are held to the same rules of attendance and examination in the extra studies as in the required studies of their class and course.

23 Any student who shall have passed a satisfactory examination in Columbia College in any study forming a part of one of the regular courses in the Schools under the Faculty of Applied Science will not be required to pursue that study.

Examinations and Standing

24 Examinations will be held at the end of the first half-year (semi-annual), or at the end of the year (annual), on all subjects taught. Examinations for debarred and deficient students will be held during the last ten days of the summer vacation. Examinations at times other than here specified are not held except upon order of the Committee on Admissions and Examinations, for reasons of weight.

25 Any student found guilty of fraudulent practices at examination will be summarily dismissed.

26 Every officer will keep a record of the scholarship of each student, and at the close of every half-year, and after the stated examination has been held each officer of instruction will report to the Dean a list of all the students who have attended his instruction, indicating their proficiency by numbers on a maximum of 10, a mark below 6 constituting a failure to pass. Each student's record will be transmitted to him at the close of each year.

27 Any student, who shall fail to pass in any of his studies at the regular semi-annual or annual examination, may present himself for a second examination at the end of the summer vacation ; failing to pass in this second examination he may be dropped from his class and required to repeat the subject with the next following class, but the Committee on Admissions and Examinations may exercise its discretion in excusing him from attendance on such a subject, holding him to such other requirements as may seem advisable ; failing a third time to pass a satisfactory examination in any study, his name may be dropped from the roll.

28 A student dropped from the roll of his class will not be permitted to attend any of the exercises of the said class without the consent of the Committee on Admissions and Examinations given for reasons of weight.

29 Students failing in any subject will not be permitted to take advanced studies for which, by reason of such deficiency, they are not properly prepared ; nor will they be allowed to attend any summer school without special permission of the Committee on Admissions and Examinations.

30 A student reported in grade 6 in any subject shall be warned by the instructor in charge thereof that his work is so unsatisfactory that, unless improved, it may result in his being found deficient at the close of the year.

31 A student reported in grade 6 in a majority of the subjects pursued by him in any year, and not reported in grade 8, or higher, in the greater part of the remainder of such subjects, will not be permitted to go on with his class without the consent of the Committee on Admissions and Examinations given for reasons of weight, but he may enter the next succeeding class, and pursue such subjects as may be required of him by the Committee.

32 Absence from the regular semi-annual or annual examination, unless excused by the Committee on Admissions and Examinations, will be counted a failure to pass that examination. This rule shall apply to examinations for delinquents held at the end of the summer vacation.

33 When a student fails to receive his degree with his class, and returns at some later period to present himself for examination for the same, he will be required to comply with all the requirements at the later date, and the same rule shall apply to students who have received one degree and make application for another.

Memoirs and Summer Work

34 During the vacations following the close of each year, memoirs on subjects, which will be assigned, are required of students in the courses of Electrical Engineering, of Analytical and Applied Chemistry, and of Architecture. The time specified for the completion and handing in of memoirs in chemistry and electrical engineering is November 1st of each year ; for other memoirs and summer work the time specified is the second Monday in October.

35 Students of the second, third, and fourth classes who fail to hand in the memoirs, drawings, and other summer work required of them under the rules by a specified time, shall not be permitted to hand them in until the beginning of the next academic year, and failing in this latter requirement they shall be dropped from the roll of the class. This requirement may be waived, for reasons of weight, in the case of students of the fourth class.

Special Students

36 Graduates of the School of Mines, the School of Chemistry, the School of Engineering, and the School of Architecture, and of other institutions of like grade and standing, may pursue any subjects taught in the schools for which they are properly qualified.

37 Permission to pursue special courses is sometimes given, for reasons of weight, to persons of mature age who are not graduates, but special students are not desired in the regular professional courses.

Laboratories and Drawing Academies

38 No student will be allowed in a laboratory or drawing academy at a time when his attendance there is not due. During hours assigned for practical work in each of the laboratories, and in the drawing academies, the attendance of students will be required. A record of the daily attendance and of the progress of each student will be kept by the officer in charge.

39 The attendance of students of the first and second classes in the drawing-room at such times as they are not engaged at lectures, between 9.30 A.M. and 1.30 P.M., is obligatory for students in engineering and architecture, for such hours and times as may be selected by the Professors of Engineering and Architecture.

Order

40 Good order and gentlemanly deportment are required of all students, as a condition of attendance.

41 Smoking is prohibited in the University buildings.

NOTE.—To render unnecessary many inquiries it is here stated that there are no dormitories attached to the University at present.

REGULATIONS FOR THE DEGREES OF MASTER OF ARTS AND DOCTOR OF PHILOSOPHY

1 Candidates for the degrees of Master of Arts and Doctor of Philosophy must hold a baccalaureate degree in arts, letters, philosophy, or science, or an engineering degree, or an equivalent of one of these from a foreign institution of learning.

The Deans of the several schools will require candidates for the higher degrees to present satisfactory evidence that they are qualified for the studies they desire to undertake.

2 Candidates for the degrees of Master of Arts and Doctor of Philosophy must pursue their studies in residence for a minimum period of one and two years, respectively.* The year spent in study for the degree of Master of Arts is credited on account of the requirement for the degree of Doctor of Philosophy. Residence at other universities may be credited to a candidate. In certain cases and by special arrangement, time exclusively devoted to investigation in the field will be credited in partial fulfilment of the time required. No degree will be conferred upon any student who has not been in residence at Columbia University for at least one year.

3 Each student who declares himself a candidate for the degrees of Master of Arts and Doctor of Philosophy, or either of them, shall, immediately after registration, designate one principal or major subject, and two subordinate or minor subjects, which shall be the studies of his university course.

* In practice three years of study is usually necessary to obtain the degree of Doctor of Philosophy.

4 The subjects from which the candidate's selection must be made are :

Under the Faculty of Philosophy

I—*Major Subjects :* 1. Philosophy ; 2. Psychology ; 3. Education ; 4. Linguistics ; 5. Literature ; 6. Music ; 7. Classical archæology and epigraphy ; 8. Greek language, literature, and history ; 9. Latin language and literature, and Roman history ; and the following, *including in each case the study of both the language and the literature :* 10. English ; 11. Germanic ; 12. Romance ; 13. Sanskrit (with Pālī) and Iranian ; 14. Semitic. Nos. 5, 11, 12, 13, and 14 count each as the equivalent of a major and one minor subject.

II—*Minor Subjects :* 1. Philosophy ; 2. Psychology ; 3. Logic ; 4. Education; 5. Anthropology ; 6. Linguistics ; 7. Literature ; 8. Music ; 9. Greek ; 10. Greek archæology ; 11. Latin ; 12. Roman archæology ; 13. Sanskrit ; 14. Iranian ; 15. English ; 16. Anglo-Saxon ; 17. Gothic ; 18. Germanic philology ; 19. German language and literature ; 20. Scandinavian languages and literature ; 21. Romance philology ; 22. French language and literature ; 23. Spanish language and literature ; 24. Italian language and literature ; 25. Hebrew ; 26. Arabic ; 27. Assyrian ; 28. Syriac ; 29. Ethiopic ; 30. Semitic epigraphy ; 31. Turkish ; 32. Armenian.

In his choice of subjects under this faculty, the candidate is limited by the regulation that not more than two of the three subjects may be selected from those offered by any one department. A major subject will involve attendance at lectures and seminars amounting to four or more hours weekly ; a minor subject will involve attendance of two or more hours weekly.

Under the Faculty of Political Science

Group I—History and political philosophy : 1. European history ; 2. American history ; 3. Political philosophy.

Group II—Public law and comparative jurisprudence : 1. Constitutional law ; 2. International law ; 3. Criminal law ; 4. Administrative law ; 5. Comparative jurisprudence.

Group III—Economics and social science : 1. Political economy and finance ; 2. Sociology and statistics.

In his choice of subjects under this faculty, the candidate is limited by the regulation that not more than two of the three subjects may be selected from any one of the above groups, and by the following rules :

Candidates offering European history as the major subject, must offer American history as one of the minor subjects, and *vice versa*.

Candidates offering political economy and finance as the major subject, must offer sociology and statistics as one of the minor subjects, and *vice versa*.

Candidates will not be permitted to offer constitutional law alone as the major subject for the degree of Doctor of Philosophy, but must combine with it the course on general international law or on comparative administrative law.

Candidates offering international law, or criminal law, or administrative law as the major subject, must take constitutional law as one minor subject.

Candidates will not be permitted to offer criminal law alone as the major subject for the degree of Doctor of Philosophy, but must combine with it the course on general international law.

To be recognized as a major subject for the degree of Master of Arts, the courses to be selected must aggregate at least two hours a week throughout the year, and must also include attendance at a seminar; for a minor subject for the degree of Master of Arts, the attendance at a seminar is not required.

To be recognized as a minor subject for the degree of Doctor of Philosophy, courses must be taken, in addition to the requirements for a minor subject for the degree of Master of Arts, aggregating two hours weekly. To be recognized as a major subject for the degree of Doctor of Philosophy, all of the courses and seminars offered in that subject must be taken.

Under the Faculty of Pure Science

Mathematics; mechanics; astronomy; geodesy; physics; chemistry; mineralogy; geology; palæontology; lithology; biology; botany; physiology; anatomy; bacteriology.

In his choice of subjects under this faculty, the candidate is limited by the regulation that no two of the subjects selected may be in any one department, unless the consent of the faculty thereto shall have first been obtained. Candidates are expected to devote at least one-half their time throughout their course of study to the major subject. In the case of laboratory courses this implies two days a week, or its equivalent, as determined by each department. Each minor subject is intended to occupy approximately one-fourth of the time during one year for the degree of Master of Arts, and during one or two years, according to the nature of the subject and the previous training of the candidate, for the degree of Doctor of Philosophy. Students may distribute the remainder of their time either in courses of major or minor reading in branches where their preparation is least complete, or in researches connected with their major subject.

Under the Faculty of Applied Science

Mining, metallurgy, engineering (civil, sanitary, electrical, and mechanical,) and architecture.

The Faculty of Applied Science requires that at least one minor subject should be taken under the Faculty of Pure Science.

A minor subject may be taken in the same department as the major, but no two minors may be taken in the same department. It is expected that fully half of the student's time throughout the course of study shall be devoted to the major subject, and one-quarter of the time during one year and an equal proportion of the second year, if necessary, to each of the minor subjects.

5 Each student is given a registration book, which is signed by the professor or instructor in charge of each course of instruction or investigation at the

beginning and end of every such course. This registration book is to be preserved by the student as evidence of work accomplished and should be submitted to the Deans of the several faculties at the end of each year, that proper credit may be given and entered on the permanent records of the institution.

6 Students desiring to be examined as candidates for any degree must make written application for such examination to the Dean of the proper faculty, on blank forms provided for the purpose. All such applications must be made on or before April 1st of the academic year in which examination is desired, and must be accompanied by the candidate's registration book.

7 Each candidate for the degree of Master of Arts shall present an essay on some topic previously approved by the professor in charge of his major subject. Before the candidate is admitted to examination, the professor in charge of his major subject must have signified his approval of such essay. This essay must be presented not later than May 1st of the academic year in which the examination is to take place. The Faculty of Political Science requires this essay to be a paper read during the year before the seminar of which the cannidate is a member.

8 Each candidate for the degree of Doctor of Philosophy shall present a dissertation embodying the result of original investigation and research, on some topic previously approved by the faculty. When such dissertation has been approved by the faculty, it shall be printed by the candidate, and one hundred and fifty copies shall be delivered to the faculty, unless for reasons of weight a smaller number be accepted by special action of the University Council. On the title-page of every such dissertation shall be printed the words : "Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy, in the Faculty of ————————, Columbia University." There shall be appended to each dissertation a statement of the educational institution that the author has attended, a list of the degrees and honors conferred upon him, as well as the titles of any previous publications.

All dissertations for the degree of Doctor of Philosophy must be submitted for approval not later than April 1st of the academic year in which examination is desired.

The several faculties have delegated the power to approve the subject chosen for his dissertation by any candidate for the degree of Doctor of Philosophy, as well as the power to approve the dissertation itself, to the professor in charge of the candidate's major subject.

In the Faculty of Political Science, with the consent of the Dean and the professor in charge of the candidate's major subject, the examination may be held before the printed dissertation is submitted.

The Faculty of Pure Science requires the dissertation to be printed in the size and form either of the Annals or Memoirs of the New York Academy of Sciences, according to the nature of the subject, and must be delivered to the faculty before the final examination.

The Faculty of Applied Science requires the dissertation to be printed in the size and style of the School of Mines Quarterly, and delivered to the faculty

not later than May 1st of the academic year in which the examination is to take place.

9 Every candidate for the degree of Doctor of Philosophy, in addition to passing such other examinations as may be required by the faculty, shall be subjected to an oral examination on his major subject, and shall defend his dissertation, in the presence of the entire faculty or of so many of its members as may desire to attend. The ability to read at sight Latin, French, and German is required by the Faculties of Philosophy and Political Science; the ability to read at sight French and German is required by the Faculties of Pure Science and of Applied Science, to be certified in each case by the Dean of the faculty concerned.

10 Students holding college degrees, who shall have completed with marked distinction one of the regular courses in the School of Law, the School of Medicine, the School of Mines, the School of Chemistry, the School of Engineering, or the School of Architecture, may be recommended for the degree of Master of Arts; provided that in each case the candidate presents a satisfactory dissertation, and that at least a part of the extra work required of him for the degree of Master of Arts be taken under the direction of either the Faculty of Philosophy, the Faculty of Political Science, or the Faculty of Pure Science, to the extent of a minor course for not less than one year.

FEES AND EXPENSES

1 Each student must pay a fee of five dollars ($5) before matriculation on entrance to the school. If an examination for entrance is required such fee must be paid by the applicant for admission before examination; and in case the examination is held at a time not appointed in previous public announcements, the fees required are ten dollars ($10).

In the case of an applicant who completes his examination for admission at the appointed entrance examinations of successive years, but one matriculation fee of five dollars ($5) is required.

2 The annual tuition fee for undergraduate students is two hundred dollars ($200), payable one-half on the first day of each half-year.

3 To insure the prompt return in good order of reagent bottles, of tools, of keys to lockers, to drawing tables, to laboratory tables, and to cover material consumed in the mechanical laboratories, a deposit of ten dollars ($10) is required. Students not making a deposit for apparatus, etc., will deposit one dollar ($1) for each key to a locker or drawing table.

There is a coat-room for those students who do not care to have lockers.

4 Every student admitted to an extra or special examination, in anticipation of the time regularly appointed, or in consequence of failure to attend, or to pass satisfactorily at any entrance, intermediate, or concluding annual examination, or any other regular examination throughout the course, is required to pay a fee of five dollars ($5) before being admitted to such examinations.

5 Every candidate for the degree of Engineer of Mines, or Civil Engineer, or Electrical Engineer, or Metallurgical Engineer, or Mechanical Engineer, or Bachelor of Science, or Master of Arts, is required to pay a fee of twenty-five dollars ($25) before being admitted to the final examinations.

6 Every candidate for the degree of Doctor of Philosophy is required to pay a fee of thirty-five dollars ($35) before being admitted to the examinations for such degree.

7 The necessary expenses of a student are:

(*a*) Board, including room-rent, fire and light, and washing, a week, from	$6.50 to $10
(*b*) Matriculation fee	5
(*c*) Extra fee, for examinations at unusual times	5
(*d*) Annual tuition fee for undergraduate students	200
(*e*) Deposit to insure return of keys, etc.	10
Or for each key to a locker or drawing table	1
(*f*) Text-books for the first class, about	15
For the second class, about	30
For the third class	25 to 50
For the fourth class, about	20
(*g*) Drawing materials for the first and second classes, each	15 to 25
For each of the other classes	5 to 10
(*h*) Laboratory apparatus for laboratory courses for each of the four years	20 to 60
(*i*) During the vacations at the close of the first, second, and third years, travelling and board for summer class in field surveying for students in the courses of Mining Engineering, Civil Engineering, Sanitary Engineering, and Metallurgy	50 to 75
(*j*) During the vacation at the close of the third year, travelling and board for summer class in practical mining for students in the courses of Mining Engineering and Metallurgy	75 to 100
(*k*) During the vacation at the close of the third year, travelling and board for summer class in practical geodesy for students in the courses of Civil Engineering and Sanitary Engineering	50 to 80
(*l*) During the vacation at the close of the third year, travelling and board for summer class in field geology for students in the courses of Mining Engineering and Metallurgy	15 to 20
(*m*) Candidates for admission to advanced standing, who attend the summer school in surveying	35
(*n*) Candidates for admission to advanced standing, who attend the summer school in practical mining	50
o) Graduation fee for undergraduate students (final examination)	25

8 The fees required of GRADUATES and SPECIAL STUDENTS attending the school, but *not candidates for a degree*, are as follows:

(*a*) Matriculation fee	$5
(*b*) Extra fee, for examinations at unusual times	5
(*c*) Full fee entitling the student to all the privileges of the school, per annum	150
(*d*) For the use of the cabinets	25
(*e*) For attendance in lecture-room and other special instruction, per annum for each hour a week of such instruction	15
(*f*) For the use of the drawing academy	25
(*g*) For the use of the laboratories, or either of them	50
(*h*) For special students in the university courses in Architecture, for each period of two months (*in advance*)	30

Should the amount of fees, exclusive of the matriculation fee, payable by any student, not exceed $100, the entire amount is payable at the beginning of the academic year, or at the matriculation of the student. Should the amount exceed $100, payment is required in two equal instalments, one at the beginning of each session of the academic year.

GRADUATES who are *candidates for degrees* must pay the matriculation fee of $5 and an annual tuition fee of $150, irrespective of the number of hours of weekly attendances for the degree of Master of Arts and the degree of Doctor of Philosophy; for other degrees, $200, and for examination,

For degree of Doctor of Philosophy	$35
For other degrees	25

Apparatus Supplies

1 Students may purchase apparatus of any of the dealers in the city.

2 To avoid inconvenience and expense to the students, and to secure a proper selection, the University undertakes, at considerable trouble and expense, to lend apparatus on the following conditions:

(*a*) Each student engaged in laboratory work, who draws apparatus from the school, must make a deposit of forty dollars ($40) with the Bursar, which deposit will be credited to him. In case of excessive draughts of apparatus an additional deposit may be required.

(*b*) Each student shall be entitled, on presenting his receipt at the apparatus-room, to draw the regular set of apparatus for qualitative analysis, for quantitative analysis, for organic analysis, for assaying, for microscopy, or for bacteriology, on account of his deposit, and from time to time to obtain ordinary articles that he may need, which will be charged to him. At the end of the year he will be credited with those articles which he returns in good order, and the value of those which he has injured or broken will be deducted from his deposit.

(*c*) The apparatus-room will be open for issuing apparatus every day at convenient hours.

(*d*) No charge is made for ordinary chemicals.

Free Tuition

Free tuition may be granted by the Committee on Admissions and Examinations in special cases, on the ground of character, ability, and need combined, but the total number of students receiving free tuition shall not exceed ten per cent. of the total number of students registered. Free tuition cannot be granted to any student during the first year of his connection with the University.

Free students shall not be exempt from the payment of fees for matriculation, for extra examination, and for examination for a degree.

Fellows shall be exempt from the payment of all fees.

Withdrawal

Students are requested, in case of withdrawal from the University during the academic year, to file a notice thereof at the office of the Bursar, who will, on application, provide the blank form for this purpose.

Committee on Aid for Students

The University Council has constituted a Standing Committee on Aid for Students, consisting at present of the following members:

Professor J. F. KEMP (School of Pure Science), Chairman.
" T. S. FISKE (College).
" G. S. HUNTINGTON (School of Medicine).
" F. M. BURDICK (School of Law).
" F. R. HUTTON (Schools of Applied Science).
" F. H. GIDDINGS (School of Political Science).
" H. A. TODD (School of Philosophy).

It is the design of the Committee to put students desiring to work their way through the different departments of the University, especially those coming from elsewhere than New York or the immediate vicinity, in the way of earning enough for their partial or complete support, or if possible to extend assistance to them in other ways, while they are pursuing their studies here. It is believed that many opportunities may be offered to students of this class if the fact of their desire to obtain employment is made known. Some of the openings likely to be available are: private tutoring, translating, copying of various sorts, teaching in evening schools, traveling companions, stenography and typewriting. All communications should be addressed to the Committee.

All the heads of clinics in the Medical School have consented to give advice without charge to students who present cards of introduction from the Committee. Such visitors are received as a general rule during office hours at private offices. This insures to students who need it, the best medical advice in the city.

FELLOWSHIPS AND OTHER PROVISION FOR THE ASSISTANCE OF STUDENTS

FELLOWSHIPS

University Fellowships

Twenty-four fellowships, known as "University Fellowships," each of the value of five hundred dollars a year, are awarded by the Council to those applicants who give evidence of special fitness to pursue courses of higher study and original investigation, the competition to be open to graduates of all colleges and scientific schools. Vacancies occurring in any of such fellowships shall be filled in the same manner in which original appointments are made.

Additional university fellows may be appointed in cases where the original appointee waives the emolument of the fellowship while accepting the honor of the appointment.

The application shall be made prior to March 1st, in writing, addressed to the President of Columbia University. Applications received later than March 1st may fail of consideration. The term of the fellowship is one year, dating from July 1st. Residence should begin October 1st.

The candidate must give evidence

(*a*) of a liberal education, such as a diploma already granted, or about to be received, from a college or scientific school of good repute;

(*b*) of decided fitness for a special line of study, such as an example of some scientific or literary work already performed;

(*c*) of upright character, such as a testimonial from some instructor.

The value of each fellowship is five hundred dollars. Payments will be based on the time during which the Fellow shall have been in residence, and are made in quarterly instalments beginning November 30th. The holder of a fellowship is exempt from the charges for tuition,

Every holder of a fellowship will be expected to perform such duties as may be allotted to him in connection with his course of study, which course shall be such as to lead to the degree of Doctor of Philosophy. He will be expected to devote his time to the prosecution of special studies under the direction of the head of the department to which he belongs, and before the close of the academic year to give evidence of progress by the preparation of a thesis, the completion of a research, the delivery of a lecture, or by some other method. He must reside in New York or vicinity during the academic year.

No holder of a fellowship shall be permitted to pursue a professional or technical course of study during his term. With the written approval of the President, but not otherwise, he may give instruction or assistance in any department of the University.

A Fellow may be reappointed at the end of a year for reasons of weight. No Fellow may be reappointed for more than two terms of one year each.

As these fellowships are awarded as honors, those who are disposed, for the benefit of others or for any other reason, to waive the pecuniary emoluments, may do so, and still have their names retained on the list of Fellows.

Tyndall Fellowship

A fellowship known as the "John Tyndall Fellowship for the Encouragement of Research in Physics" is held by some suitable person, who is either a graduate of or a student in the University, but not necessarily a candidate for a degree. Such Fellow shall be appointed by the Council upon a recommendation of the head of the department of Physics. Such appointment shall always be for the term of one year only, but the Fellow, for the time being, shall be eligible for appointment from year to year, upon like recommendation. The Fellow so appointed shall be entitled to receive during his term of office the net income of the capital sum constituting the endowment, to be paid in four equal quarterly instalments on the usual quarter days, upon the certificate of the President ; and the Trustees guarantee that such net income will amount to at least six hundred and forty-eight dollars a year, being six per cent. upon ten thousand eight hundred dollars, the fund presented to the University by Professor Tyndall.

Barnard Fellowship

A fellowship known as the "Barnard Fellowship for Encouraging Scientific Research" is held by a graduate of the College or of the Schools of Mines, Chemistry, Engineering, or Architecture who has evinced decided aptness for physical investigation and who may be disposed to devote himself to such investigation for some years continuously. Such Fellow shall be appointed by the Council upon the joint recommendation of the Faculties of the College and Applied Science. Such appointment shall be for the term of one year only, but the Fellow, for the time being, shall be eligible to reappointment from year to year upon like joint recommendation. The Fellow so appointed shall be entitled to receive during his term of office the net income of the capital sum constituting the endowment, to be paid to him in four equal quarterly instalments on the usual quarter days, upon the certificate of the President.

Duties of Tyndall and Barnard Fellows

It shall be the duty of a "John Tyndall" or "Barnard" Fellow to devote himself faithfully to the investigation of some subject in physical science at this University, or at some other in this country or abroad, under the supervision of some known physicist approved by the President and the head of the department of Physics. He shall make a report quarterly to the President, giving an account of the work in which he has been engaged during the three months preceding ; which report shall be certified by the physicist superintending and directing him. In case of failure faithfully to fulfil the obligations imposed upon him, such Fellow shall forfeit all privileges and emoluments conferred upon him by his appointment to the fellowship, and the Council may at any time declare the fellowship to be vacant.

Columbia Fellowship

A fellowship known as the "Columbia Fellowship in Architecture," which shall be open to all graduates of the department of Architecture less than thirty years of age, is awarded under such rules and regulations as shall from time to time be determined by the President and the Professor of Architecture. Holders of such fellowships shall devote the income thereof to foreign study and travel in accordance with plans prepared by themselves and approved by the President and such professor, and shall upon return present a written report and exhibit drawings in the department of Architecture. Said fellowship shall be awarded in the spring of every even-numbered year, and payments thereof shall be made by the Treasurer, on the certificate of the Professor of Architecture, endorsed by the President, in four equal quarterly instalments of three hundred and twenty-five dollars each on the usual quarter days.

McKim Fellowship

A fellowship known as the "McKim Fellowship in Architecture" is awarded upon like conditions and for like purposes as are specified in the foregoing section, but such fellowships shall be awarded in the spring of every uneven-numbered year, and payments thereof shall be made by the Treasurer, on the certificate of the Professor of Architecture, endorsed by the President, in eight equal instalments of two hundred and fifty dollars each on the usual quarter days. The holder of this fellowship shall remain abroad two years, ten months of which he shall spend as a student of the *American School of Architecture in Rome.*

FELLOWSHIP REGULATIONS

No Fellow shall be allowed to accept remunerative employment except by permission of the President, and the acceptance of any such employment, without such permission, shall operate to vacate the fellowship.

All Fellows, except as hereinbefore provided, shall be required to pursue their studies during the term of their fellowship at the University, unless permission be granted them by the President to study elsewhere.

All Fellows shall be governed by such rules and regulations, not inconsistent with the Statutes, as may be prescribed by the Council.

DEVEREUX PRIZE

A prize of one hundred dollars has been offered by Mr. W. B. Devereux (School of Mines, '78) to graduates of the School of Mines for the best memoir on the electric transmission of power for mining purposes. The memoir should describe in detail, with the necessary drawings, an existing plant or plants, and the practical results obtained therefrom, giving if possible the cost of installation and working. Preference will be given to memoirs describing plants with which the writer has had personal connection either in the design, the construction, or the operation of the same.

Memoirs must be handed in to the Dean of the Faculty on or before December first, 1897.

PRIVILEGES OPEN TO COLUMBIA STUDENTS IN OTHER INSTITUTIONS

The American Museum of Natural History places its collections at the service of advanced students of Columbia University for the purposes of study and research, and provides them with the necessary facilities for work.

The Metropolitan Museum of Art admits students of Columbia University to the Museum on presentation of their matriculation cards, and gives them permission to draw, sketch, or copy objects in the Museum, the curator of the department in which the student desires to work furnishing him with cards for the work.

Objects may be removed temporarily from exhibition for the purpose of special study, and students are allowed to study these objects in rooms specified for the purpose.

LIBRARY

The library is open to all officers, students, and graduates, for borrowing and reference, daily, except Sundays, Good-Friday, Fourth of July, Thanksgiving day and Christmas day, throughout the year, including all other holidays and vacations.

It contains over 230,000 volumes, and is rapidly growing. It has full sets of nearly all important journals, transactions, and official reports in mining, metallurgy, geology, chemistry, physics, mathematics, and the other pure and applied sciences. More than 900 serials are regularly received. All important works in pure and applied science are usually purchased as they appear.

The architectural library is also accessible to students in the evening.

PUBLIC WORSHIP

Prayers are read in the University Chapel every week-day, except Saturday, at 12.30 P.M., with the reading of the Scriptures and singing, and a short address by the Chaplain. All officers and students of the University are invited to be present.

Thomas Arkle Clark

Third Series, No. 15 May 2, 1903

Columbia University Bulletins of Information

SCHOOL OF MINES
SCHOOL OF CHEMISTRY
SCHOOLS OF ENGINEERING

GENERAL INFORMATION

1903-1904

Published by
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New York, N. Y.

Columbia University
Bulletins of Information

(Issued 25 times during the Academic Year, monthly in November and December, and weekly between February and June. Entered as second-class matter at the New York, N. Y., Post Office, Dec. 22, 1900, under Act of July 16, 1894.)

These include:

1. The President's Annual Report to the Trustees.
2. The Catalogue of the University, issued in December, price 25 cents.
3. The Announcements of the several Colleges and Schools and of certain Divisions, issued in the spring, and relating to the work of the next year. These are made as accurate as possible, but the right is reserved to make changes in detail as circumstances require. The current number of any of these Announcements will be sent without charge upon application to the Secretary of the University. (For information as to the various Courses offered by the University see the last page of this Announcement.)

NOTE

This Bulletin is intended to give general information covering administrative and other details concerning the Schools of Columbia University under the Faculty of Applied Science. These are:

THE SCHOOL OF MINES

THE SCHOOL OF CHEMISTRY

THE SCHOOLS OF ENGINEERING

Under the University organization of Divisions these include:

The Division of Chemistry
" " " Engineering, comprising the Departments of
Civil Engineering
Electrical Engineering and
Mechanical Engineering
" " Mining and Metallurgy

In addition to the above, students under this Faculty attend courses in the Division of Mathematical and Physical Science, including Astronomy, Mathematics, Mechanics, Physics, and in the Division of Geology, Geography and Mineralogy.

In connection with this Circular of General Information, the student should consult the special Bulletins of the Divisions containing the detailed Announcements of those courses offered under the Faculty of Applied Science in which he may be interested.

Copies of any or all of these Announcements will be sent, postpaid, upon application to the Secretary of Columbia University.

PRESIDENT

NICHOLAS MURRAY BUTLER, Ph.D., LL.D

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GENERAL STATEMENT

Columbia University was founded in 1754 as King's College. In 1784, after the Revolutionary War, King's College became, by act of the Legislature of the State of New York, Columbia College. The institution whose name was thus changed has become Columbia University.

The first step for the foundation of a School of Applied Science was taken in 1864, when the Trustees approved the creation of a School of Mines, in which courses were later established in civil engineering, chemistry, and metallurgy. The growth of these courses, and the addition of the course in architecture during the decade of 1880 to 1890, made it seem desirable to adopt some more comprehensive name than the historic title "School of Mines," so that in 1896 the Schools of Engineering, Chemistry, and Architecture were set off from the School of Mines, which remained, however, as one of the Schools of Applied Science under its appropriate Faculty. Each School, therefore, conducts separate courses of study leading to the appropriate degree.

The School of Architecture, which has been under the jurisdiction of the Faculty of Applied Science, became by action of the Trustees of the University a separate School on July 1, 1902.

The announcement of the Division of Fine Arts, which may be had upon application to the Secretary of the University, gives full information as to the work of this School. The requirements for entrance are the same as those to the Schools of Applied Science.

The work of Columbia College is so related to that of the various faculties of the University as to enable a student, while still securing a liberal education, to begin to prepare himself during his college course for the specialization, whether of a professional or a non-professional character, that is to follow. In particular, the regulations are so framed that, under certain conditions, a student can complete his college and law course in six years, and his college and medical course in seven years, while taking a four-year course in medicine and a three-year course in law. Similarly, the college course can be combined with any of the courses in applied science in the Schools of Mines, Chemistry, and Engineering, in such a way as to complete the two courses together, each of which by itself is four years in length, in either six or seven years, as the student may prefer.

COURSES OF STUDY

Columbia University offers opportunity for the study of science in several faculties and schools, namely:

1. In Columbia College, the undergraduate department of the University.
2. In the School of Mines, the School of Chemistry, and the School of Engineering, which are professional schools under the charge of the Faculty of Applied Science.
3. In the university courses conducted by the Faculty of Applied Science and by the Faculty of Pure Science.

Professional Courses

The Faculty of Applied Science has charge of the following schools:

1. The School of Mines, with four-year courses leading to the degrees of Engineer of Mines and Metallurgical Engineer.

2. The School of Chemistry, with four-year courses in Analytical, Industrial, and Organic Chemistry, leading to the degree of Bachelor of Science.

3. The School of Engineering, with four-year courses in Civil Engineering, Sanitary Engineering, Electrical Engineering, and Mechanical Engineering, the first two leading to the degree of Civil Engineer, and the others to the degree of Electrical Engineer and Mechanical Engineer respectively.

Full particulars regarding each of these courses of study are contained in special circulars, which will be forwarded on application to the Secretary of the University.

These courses are intended to meet the requirements of the several professions indicated. Many of the courses permit a certain amount of specialization, particularly in the fourth year. The courses in the School of Mines are so arranged that the student can emphasize the engineering, the metallurgical, or the geological side of his profession, while one of the alternative courses in Mechanical Engineering is designed for those who wish to make a specialty of mine plant and machinery. A course in Sanitary Engineering (leading to the degree of Civil Engineer) is provided for those who wish to prepare themselves for this important branch of civil engineering. The Mechanical Engineering course offers five alternatives in the fourth year, emphasizing, respectively, the dynamic, the electrical, the mining, the marine, and the locomotive sides of the mechanical engineer's work. Three courses are offered in Chemistry: for analytical chemists, industrial chemists, and organic chemists, respectively.

Modifications of Regular Courses

Under proper restrictions, and for reasons of weight, a student will be permitted to substitute one study for another in any of the regular courses (see By-Law 2, page 12). By taking advantage of this provision students can fit themselves for special lines of professional work without losing their degree.*

Special Privileges for Graduate Students

Graduates of colleges or scientific schools are admitted to advanced standing in any of the regular professional courses, as candidates for a

* It is particularly recommended, for example, that students whose professional work is likely to take them to Spanish America should arrange for a proper course in the Spanish language.

degree. Such students are given credit for all courses of which they have had the substantial equivalent, and are permitted to take any course of study for which they are qualified. If possible, such students should make arrangements to attend, before entrance, the required summer classes of the course which they intend to take.

University Courses in Applied Science

The Faculty of Applied Science has charge of candidates for the degrees of Master of Arts and Doctor of Philosophy who desire to undertake advanced study or special investigations in mining, metallurgy, or engineering (civil, sanitary, electrical, and mechanical). Information as to these higher degrees will be found on pages 16 to 22 inclusive.

University Courses in Pure Science

The Faculty of Pure Science has charge of all advanced work leading to the degrees of Master of Arts and Doctor of Philosophy in the physical sciences (chemistry, physics, and chemical physics); in the mathematical sciences (pure mathematics, mechanics, mathematical physics, astronomy, and geodesy); and in the natural sciences (mineralogy, lithology, geology, bacteriology, botany, zoölogy, palæontology, physiological chemistry, and physiology). The general Announcement of these Faculties, and the special Bulletins of the Divisions of Biology, Chemistry, Geology, Geography, and Mineralogy, and Mathematical and Physical Science may be obtained on application to the Secretary of the University.

SCHOOLS OF APPLIED SCIENCE

ADMISSION

The Committee on Admissions of the Schools of Applied Science has charge of all matters relating to this subject.

Candidates for admission to the First-year class, at its formation, must be at least eighteen years of age; and for admission to advanced standing there is required a corresponding increase of age; but this rule may be dispensed with when, in the opinion of the Committee, there are sufficient reasons to justify its relaxation.

Every candidate must, before admission, present a certificate of good moral character from his last teacher, or from some citizen in good standing, and students from other institutions must bring certificates of honorable dismission.

Students are admitted subject to the provisions of the Statutes of the University in regard to discipline.

Requirements for Admission

Every candidate for admission to the First-year class is required at the entrance examinations to offer subjects amounting to fifteen points * as indicated below.

The candidate *must* offer:

Mathematics, elementary and advanced,	counting	4 points
Physics	"	1 point
Chemistry	"	1 "
Drawing	"	1 "
English	"	3 points
Elementary History	"	1 point
Elementary German	"	2 points
and two points from one of the following subjects:		
Elementary French	"	2 points
Spanish	"	2 "
Elementary Latin	"	2 "

Entrance Examinations

Examinations for admission are held twice each year, in June and in September. In 1903 they will begin on June 20 and September 14, respectively.

In June, 1903, the entrance examinations will be those of the College Entrance Examination Board, of which Columbia University is a member.

In September, 1903, the entrance examinations will be conducted by the Columbia University Committee on Entrance Examinations and will be held only at the University. The College Entrance Examination Board at present holds no examinations in September.

A candidate may take examinations in June (but not in September) of the year preceding that in which he purposes to enter the University. Such examinations are known as preliminary examinations. At his preliminary examination a candidate may, with the approval of his principal instructor, offer any subject or numbered part of a subject.

In the year in which he proposes to enter the University, a candidate may divide his examinations between June and September in whatever manner he may wish, and he may offer again in September any subject in which he may have failed at the June examinations.

The results of an entrance examination are allowed to stand to the credit of a candidate for sixteen months, but not longer.

In both June and September, 1903, entrance examinations will be conducted in the Columbia University Gymnasium.

* The several subjects are stated in terms of units; the unit is a course of five periods weekly throughout an academic year of the preparatory school; the subjects are assigned units in accordance with the time required to prepare adequately upon them for college entrance.

In June, extrance examinations will also be held at a large number of widely distributed points. A complete list of the places of examination may be obtained from the Secretary of the College Entrance Examination Board, Post Office Sub-Station 84, New York, N. Y.

A copy of the time-scheme of the examinations held by the College Entrance Examination Board in June, and by Columbia University in September, 1903, together with information as to the proper method of filing application blanks for these examinations, the payment of fees, and the division of examinations, and also detailed definitions of the requirements in each subject which may be counted for admission to the Schools of Applied Science, is given in the Announcement of the Entrance Examinations for 1903, which may be had upon application to the Secretary of the University.

Certificates in Lieu of Entrance Examinations

The Committee on Admissions in general accept, in lieu of examinations, no credentials except the Regents' Academic Diploma * and the certificates of universities and colleges in good standing.

These credentials are accepted only for the ground which they specifically cover.

All credentials offered in lieu of entrance examinations must be sent to the chairman of the Committee on Admissions of the Schools of Applied Science at least one week before the first day of the entrance examinations; in 1903 not later than September 7. The names of those candidates whose certificates are accepted in whole or in part will be posted on the Bulletin Board at least one day in advance of the beginning of the examinations.

The certificates of the preparatory or high-school departments of universities and colleges are not accepted.

Candidates must take the regular entrance examinations in the subjects in which their certificates are not deemed adequate.

Report of Entrance Examinations

The Committee on Admissions will report to the Dean as soon as possible after the conclusion of the Entrance Examinations the names of those candidates who, having passed a satisfactory examination, may be admitted with or without conditions, or those who must present themselves for re-examination in September, and of those who have been rejected.

* For 1903–04 every Regents' Academic Diploma is considered as covering the entrance requirement in English. No Regents' Academic Diploma will be accepted in lieu of the entrance examination in French unless it covers a two-year high-school course in French as recognized by the Regents. Similarly, no Regents' Academic Diploma will be accepted in lieu of the entrance examination in German unless it covers a two-year high-school course in German. In the case of the natural sciences, a Regents' Academic Diploma will not be accepted for the required laboratory work unless accompanied by the certified note-book of laboratory work.

Candidates taking examinations with the College Entrance Examination Board in June should send the report thereon to the Registrar of Columbia University immediately upon its receipt.

The Committee on Admissions will report to the Registrar not later than one week after the conclusion of the entrance examinations in September the names of those candidates who, upon a final showing, may be admitted with or without conditions, and of those who have been rejected.

Except for reasons of weight no student will be admitted with a condition in Mathematics, Chemistry, or Physics.*

Admission to Advanced Standing

Candidates for admission from other universities or colleges, and those desiring to be admitted to advanced standing on examination, must make application in writing to the Committee on Admissions. Proper blanks for the purpose may be obtained from the Secretary of the University. These should be returned when filled out accompanied by a catalogue of the institution from which the transfer is to be made, in which the applicant has distinctly marked the courses which he has completed and the subjects which he offered for admission. The application should be made at least one week before the first day of the September entrance examinations.

Each candidate for a degree seeking admission to advanced standing must show that he has attained proficiency in the equivalents of:

1. The requirements for admission to the First-year class.
2. All the prescribed studies already pursued by the class to which he seeks admission.

A candidate may be admitted notwithstanding deficiencies in some of these studies, but no candidate will be recommended for a professional degree until he shall have brought all his studies up to the point required for that degree.

Each candidate from another university or college is expected to furnish official statements of his record in his various studies, and letters or other evidence showing the opinion of his instructors in regard to his scholarship and character.

No applicant will be allowed to enter the Fourth-year class as a candidate for a degree after October 15 in any year.

Special Students

Graduates of the School of Mines, the School of Chemistry, and the School of Engineering, and of other institutions of equal grade, may

* It is suggested that candidates deficient in these subjects in June arrange to take courses in them in the Summer Session of Columbia University, the announcement of which will be sent upon application to the Secretary of the University.

pursue any subjects taught in the schools for which they are properly qualified.

Except for reasons of weight, satisfactory to the Committee on Admissions, no one will be received as a special student who is unable to meet the regular entrance requirements, or who has, within ten months of the time of his application, been rejected as a regular student, or has, within that period, become deficient as a regular student. No one will be admitted as a special student who wishes merely to pursue elementary subjects included among the requirements for admission to the College or Schools of Applied Science.

Persons of mature age who are not graduates, but who show special qualifications, are sometimes permitted to pursue special courses, but this permission is not given to others.

In the courses which they severally pursue special students will be held to the observance of the same regulations as to attendance, examination, proficiency, and deficiency as regular students.

MATRICULATION, REGISTRATION, AND ENROLMENT

Every student will be required, as a condition of admission to the Schools of Applied Science, to matriculate on a blank prepared for the purpose, upon which he shall state his name, place of abode, and post-office address, and, if he be under twenty-one years of age, the name, place of abode, and post-office address of his father or guardian, and such other information as may be from time to time required.

A student is required to matriculate but once, upon first connecting himself with the University. Registration consists in furnishing to the Registrar, upon blanks provided for the purpose, such information as the University may request. Enrolment consists in filing, upon blanks provided for the purpose, a statement of the courses which a student may be authorized to pursue.

At the opening of the year, all students are required to present themselves at the office of the Registrar, 109 Library, for registration and enrolment from Wednesday, September 16, to Tuesday, September 22, 1903, all new students being allowed an additional day for registration, viz., Wednesday, September 23. Registration and enrolment at a later date are permitted to candidates who obtain the written consent of the Dean, satisfactory cause for the delay having been shown, and who pay the additional fee of five dollars ($5) for the permission. Students permitted to register at a later date are required to pay the full charge for tuition for the half-year in which they register. Credit for attendance will date from September 23. All students will be held strictly accountable for absences incurred owing to enrolment at a later date, unless excused by the Dean.

Students holding scholarships are required to report themselves as in residence to the Registrar during the first week of the first and the second half-years. (See page 28.)

Withdrawal

Students are requested, in case of withdrawal from the University during the academic year, to file a notice thereof at the office of the Registrar, who will, on application, provide the blank form for this purpose.

Honorable Dismissal

An honorable discharge shall always be granted to any student in good standing who may desire to withdraw; but no student under the age of twenty-one years shall be entitled to a discharge without the assent of his parent or guardian, given in writing to the President.

Payment of Fees

Fees (see p. 22) must be paid on or before the fourth Saturday in October for the first term, and the third Saturday in February for the second term, and no rebate of fees for either term may be expected after those dates.

BY-LAWS OF THE FACULTY

1. No student is allowed to be a candidate for more than one of the professional degrees at the same time.

2. For reasons of weight the substitution of a subject in any professional course for an approved equivalent may be made by the Dean on the request of any candidate for a degree, provided that such substitution have the approval of the heads of the departments concerned and of the department giving the technical instruction that leads to the degree for which the student is a candidate.

3. Prompt and regular attendance is required of every student upon the exercises and examinations of the courses for which he is enrolled.

4. The instructor in each subject shall keep a careful record of the attendance, and, as far as practicable, of the scholarship of all students entitled to attend that subject. It shall be the duty of the instructor to warn any student found deficient in scholarship or irregular in attendance, and if such deficient scholarship or irregular attendance continue thereafter he shall report his name through the head of the department to the Dean.

5. Any student so reported may be put upon probation by the Dean, or debarred by him from examination after due opportunity for personal explanation.

6. The Dean may also debar from examination in any subject any student reported to him as having incurred, with or without good reason, absences so numerous that, in the judgment of the head of the department concerned, it has become essential that he should repeat that subject; and any student so debarred shall not be admitted to examination in that subject until he has attended the full course therein.

7. By special permission of the Dean, with the concurrence of the head of the department concerned, students may attend exercises not required in the class or subject to which they belong, provided that such attendance does not interfere with the required exercises of their class. Such students are held to the same rules as to attendance and examination in their extra studies as in the required studies of their class.

8. Any student who shall have passed a satisfactory examination in Columbia College in any study forming a part of one of the professional courses in the Schools under the Faculty of Applied Science will not be required to pursue that study a second time.

Examinations and Standing

9. Examinations will be held at the end of the first half-year (mid-year), or at the end of the year (final). Examinations for students debarred or deficient at the regular examinations will be held during the two weeks preceding the opening of the first half-year, and for members of the fourth class only, and for subjects belonging to that year only, in the first week in May. In the case of subjects and courses which require the use of collections and apparatus, the delinquent examination will be held during the week following the holidays at Christmas.

10. A student found deficient in a subject at any of the stated examinations above provided will not be allowed a special examination in that subject.

11. A student absent from the regular mid-year, final, or delinquent examinations will be considered to have failed to pass that examination, and will not be allowed a special examination in that subject, except that, if the absence was due to unavoidable circumstances, the Dean may, on proper written certification of these circumstances, grant a special examination.

12. The fee for special examination is $5.00, which must be paid by the student before being admitted to the examination. If a student has special examinations in several subjects granted to him under one permit from the Dean, specifying each subject, one fee of $5.00 shall cover them all.

13. Every officer, after the stated examinations have been held, shall report to the Registrar a list of all students who have attended his instruction, indicating their proficiency by numbers on a maximum of 10, a mark below 6 constituting a failure to pass. A student reported in grade 6 in a majority of the subjects pursued by him in any year, and not reported in grade 8 or higher in the greater part of the remainder of such subjects, will not be permitted to go on with his class without the consent of the Dean and the head of the department giving the technical instruction that leads to the degree for which the student is a candidate. This consent will be given only for reasons of weight.

but the student may enter the next succeeding class and pursue such subjects as may be required of him. Each student's record will be transmitted to him at the close of each year.

14. Any student who shall fail to pass in any of his studies at the regular mid-year or final examinations shall present himself for a second examination as above provided under the By-Laws; failing to pass in this second examination he shall be dropped from his class and required to repeat the subject with the next following class, but the Dean may exercise his discretion in excusing him from attendance on the exercises of such a subject, holding him to such other requirements as may seem advisable; failing a third time to pass a satisfactory examination in any study, his name shall be dropped from the roll of the school. A student so dropped shall have the right of appeal to the Faculty.

15. Students shall be enrolled in the class in which at least 75% of their hours are taken; provided, however, that no student shall be advanced from the first to the second class who has any entrance condition in Mathematics, Chemistry, or Physics; no student shall be advanced to the third class who has any entrance conditions or any deficiencies of the first year; no student shall be admitted to the fourth class who has any deficiency in the first or second year, or more than one deficiency in the third year. A student dropped from the roll of his class shall not be permitted to attend any of the exercises of the said class without the consent of the Dean given for reasons of weight.

16. Students failing in any subject shall not be permitted to take advanced studies for which, by reason of such deficiency, they are not prepared; nor will such students be allowed to attend any Summer School without permission of the Dean.

17. Students who have received one degree and make application for another in the Schools of Applied Science must comply with all the requirements for that degree in force at the date of application.

Memoirs and Summer Work

18. During the vacations following the close of each year, memoirs, on subjects which will be assigned, are required of students in the courses of Civil Engineering, Electrical Engineering, Mechanical Engineering, of Analytical, Industrial, and Organic Chemistry. The time specified for the completion and handing in of memoirs in chemistry and electrical engineering is November 1 of each year; for other memoirs and summer work the time specified is the second Monday in October.

19. Students of the second, third, and fourth classes who fail to hand in the memoirs, drawings, and other summer work required of them under the rules by a specified time, shall not be permitted to hand them in until the beginning of the next academic year, and failing in this latter requirement they shall be dropped from the roll of the class. This requirement may be waived, for reasons of weight, in the case of students of the fourth class.

Laboratories and Drawing Rooms

20. No student will be allowed without permission in a laboratory or drawing room at a time when his attendance there is not due. During hours assigned for practical work in the laboratories and drawing rooms, the attendance of students is required.

Collegiate Preparation Recommended

Candidates intending to enter the School of Mines, the School of Chemistry, or the School of Engineering are recommended to take advantage of the opportunities offered in Columbia College, the undergraduate department of the University. Under this curriculum, students, at the end of four years, may obtain the degree of Bachelor of Arts, and may at the same time prepare themselves to enter the third year of any of these professional schools, and take their technical degrees two years later. As students may and do enter the College two years earlier than they enter the professional schools, they will be able by taking this combined course of study to obtain the professional degree at the same age as though they entered the professional school in the first instance at the present average age. This combined six-year course is strongly recommended, for the reason that engineers, and chemists, as professional men, need the liberal training offered by a collegiate course quite as much as do lawyers, physicians, or clergymen. Experience has shown that those who have taken a liberal course of study, and who have enjoyed the advantages of such an education before beginning their technical studies, have taken a much higher standing in their profession, have exercised greater influence in the community, and have been much more useful men, than those who have relied upon a purely scientific or professional course of study.

Without sacrificing the necessary elements of a liberal education, the widest opportunity for elective work in science is offered in the curriculum of the College, which will permit the student to pursue almost any desired line of study, and to specialize in it to almost any desired extent. A properly chosen course of study in the College will thus fit students for advanced work and original investigation, and is recommended to those intending to become candidates for higher degrees under the Faculty of Applied Science or the Faculty of Pure Science.

For details, see the Announcement of Columbia College, which will be sent on application to the Secretary of the University.

REGULATIONS FOR THE DEGREES OF MASTER OF ARTS AND DOCTOR OF PHILOSOPHY

The degrees of Master of Arts and Doctor of Philosophy are awarded by the University Council upon the recommendation of the Faculty of Applied Science for advanced work in Mining, Metallurgy, Civil and Sanitary Engineering, Electrical Engineering, and Mechanical Engineering. Candidates must hold a baccalaureate degree in arts, letters, philosophy, or science, or an engineering degree, or an equivalent of one of these from a foreign institution of learning.

Every candidate for a higher degree must present to the Dean of each school in which he intends to study satisfactory evidence that he is qualified for the studies he desires to undertake.

Candidates for the degrees of Master of Arts and Doctor of Philosophy must pursue their studies in residence for a minimum period of one and two years, respectively.* The year spent in study for the degree of Master of Arts is credited on account of the requirement for the degree of Doctor of Philosophy. Residence at other universities may be credited to a candidate. In certain cases and by special arrangement, time exclusively devoted to investigation in the field will be credited in partial fulfilment of the time required. No degree will be conferred upon any student who has not been in residence at Columbia University for at least one year.

Each student who declares himself a candidate for the degrees of Master of Arts and Doctor of Philosophy, or either of them, shall, immediately after registration, designate one principal or major subject and two subordinate or minor subjects.

Candidates are expected to devote at least one half of their time throughout their course of study to the major subject. In the case of laboratory courses this implies two days a week, or its equivalent, as determined by each department. Each minor subject is intended to occupy approximately one fourth of the time during one year for the degree of Master of Arts, and during two years for the degree of Doctor of Philosophy.

Minor subjects may not be changed except by the permission of the Dean, to be given only on the written recommendation of the heads of the departments from which and to which the change is desired; major subjects may not be changed except by a special vote of the Faculty in each case.

With the consent of the Dean of the Faculty concerned and of the professor in charge of his major subject, a candidate may select both minor subjects within the same department, and may divide a minor subject, taking parts of two subjects germane to his major subject.

The Faculty of Applied Science requires that at least one minor subject be taken under the Faculty of Pure Science.

* In practice three years of study are usually necessary to obtain the degree of Doctor of Philosophy.

The general regulations regarding registration, the preparation and presentation of the essay required for the degree of Master of Arts and the dissertation required for the degree of Doctor of Philosophy, and for the examinations for these degrees will be found in the Bulletin dealing primarily with graduate work (*The Announcement of the Faculties of Political Science, Philosophy, and Pure Science*).

It should be noted that the Faculty of Applied Science requires the dissertation for the degree of Doctor of Philosophy to be printed in the size and style of the School of Mines *Quarterly*, and delivered to the Faculty not later than May 1 of the academic year in which the examination is to take place.

The attention of candidates for a professional degree in Applied Science is called to the following provision:

Students holding college degrees, who shall have completed with marked distinction one of the regular courses in the School of Mines, the School of Chemistry, or the School of Engineering, may be recommended for the degree of Master of Arts; provided that in each case the candidate, while pursuing his professional course, shall have taken additional work, under the direction of the Faculty of Pure Science, to the extent of a minor subject, for not less than one academic year.

Every such candidate shall present an essay on some topic previously approved by the professor in charge of his minor subject. Before the candidate is admitted to examination, the professor in charge of his minor subject must have signified his approval of such essay. This essay must be presented not later than May 1 of the academic year in which the examination is to take place.

Courses of Study and Research for the degrees of A.M. and Ph.D. under the Faculty of Applied Science *

Civil Engineering **5**—Elasticity and Resistance of Materials. 3 hours first half-year, and 2 hours second half-year, with 6 hours problem and design work. Counts as a minor for the degree of A.M.

For details of this and following courses see circular of Civil Engineering courses, which will be sent on application.

Civil Engineering **18**—Foundations, including Theory of Earth Pressures (Civil Engineering **11** with added conferences and reading). 2 hours, with 5 hours problem and design work. Counts as a minor for the degree of A.M.

Civil Engineering **19**—Hydraulics (Civil Engineering **12** with additional reading). 2 hours, with 5 hours laboratory and problem work. Counts as a minor for the degree of A.M.

* The Faculty of Applied Science offers courses in Civil, Electrical, and Mechanical Engineering, Metallurgy, and Mining. Courses in Applied Chemistry, Physics, Mechanics, and other branches of the physical, mathematical, and natural sciences are given under the Faculty of Pure Science, and will be found detailed in the announcements of the Divisions of Biology, Chemistry, and of the Mathematical and Physical Sciences, any of which will be sent on application.

Civil Engineering 20—Long-Span Bridges. Open to those who have taken Civil Engineering **10**. Conferences with reading and design work as required. Counts as a minor for the degree of A.M.

Civil Engineering 21—Elastic and Masonry Arches. Open to those who have taken Civil Engineering **4**. Conferences, reading, and design work as required. Counts as a minor for the degree of A.M.

Civil Engineering 22—Sanitary Engineering. May be taken as a major for the degree of A.M. or Ph.D.

Civil Engineering 23—Hydraulic Engineering, including the hydraulics of rivers and power plants, and municipal water-works. May be taken as a major for the degree of A.M. or Ph.D.

Civil Engineering 24—Municipal Engineering, including water-works, sewers and sewage works, streets and other public work, and their administration. May be taken as a major for the degree of A.M. or Ph.D.

Civil Engineering 25—The Engineering of Structures, including long-span bridges and deep foundations, and methods of building them, and advanced work in elasticity and resistance of materials. May be taken as a major for the degree of A.M. or Ph.D.

Electrical Engineering 1, 4, and 10—Dynamo and Motor Practice. Electric Lighting, and Electrical Laboratory. 3 hours, and 5 hours laboratory. Pre-requisite: Course **7**. Count together as a minor for the degree of A.M.

For the details of this and following courses, see circular of the courses in Electrical Engineering, which will be sent on application.

Electrical Engineering 2, 11, 21, 22, and 23—Electric Power, Management of Electric Plants, Electrical Laboratory, and Electrical Distribution. 3 hours and 2 afternoons throughout the year. Prerequisites: Physics **3**, and Electrical Engineering **1**, **4**, and **10**. Count together as a minor for the degree of A.M.

Electrical Engineering 11—Electrical Engineering Laboratory, with Mechanics **8** and **9**. 3 hours first half-year, 2 hours second half-year, and 2 afternoons laboratory work throughout the year. Prerequisites: Course **10**, Mechanics **7**. Count together as a minor for the degree of A.M.

Any two of the above minors in Electrical Engineering may be taken together as a major for the degree of A.M.

Electrical Engineering 23—Special problems and original investigations in advanced Electrical Engineering, with conferences and laboratory work as required. Pre-requisite: all the courses in the department of Electrical Engineering. Major for the degree of Ph.D.

Mechanical Engineering 16, 22, and 28—Testing materials of Engineering, Engineering Design and Drawing, Steam Engine Design

and Advanced Drawing. 3 hours lectures with laboratory and design work. May be taken together as a minor for the degree of A.M.

Pre-requisite for this and the following majors and minors, or to be taken at the same time, Mechanical Engineering 10, 11, 12, and 13. For details see special announcement circular of courses in Mechanical Engineering, which will be sent on application.

MECHANICAL ENGINEERING 20, 21, 23, 25, 27, AND 28—Motors other than Steam, Dynamics of Motors, Valve Gearing for Engines, Experimental Mechanical Engineering Laboratory. 4 hours lectures with laboratory and design work. Taken together count as a minor for the degree of A.M.

MECHANICAL ENGINEERING 17, 23, 24, AND 28—Mechanical Engineering Laboratory, Valve Gearing for Engines, Heat and Steam Engineering Laboratory, Steam Engine Design and Advanced Drawing. 3 hours lectures with laboratory and design work. Taken together count as a minor for the degree of A.M.

MECHANICAL ENGINEERING 17, 18, 24, AND 28—Laboratory, Machinery and Mechanism, Heat and Steam Engineering Laboratory, Steam Engine Design and Advanced Drawing. 4 hours lectures with laboratory and design work. Taken together count as a minor for the degree of A.M.

MECHANICAL ENGINEERING 19, 24, 28, AND 50—Heat and its applications, Laboratory, Steam Engine Design and Advanced Drawing. 4 hours lectures with laboratory and design work. Taken together count as a minor for the degree of A.M.

MECHANICAL ENGINEERING 24, 26, AND 28—Heat and Steam Engineering Laboratory, Railway Motive Power and Machinery, Steam Engine Design and Advanced Drawing. 3 hours lectures with laboratory and design work. Taken together count as a minor for the degree of A.M.

MECHANICAL ENGINEERING 14, 19, 20, 21, 23, 28, AND 50—Experimental Mechanical Engineering, Heat and its applications, Motors other than steam, Dynamics of Motors, Valve Gearing for Engines, Steam Engine Design and Advanced Drawing. 6 hours lectures with laboratory and design work. Taken together count as a major for the degree of A.M.

MECHANICAL ENGINEERING 17, 21, 22, 25, 27, AND 28—Laboratory, Dynamics of Motors, Engineering Design and Drawing, Experimental Mechanical Engineering Laboratory, Pumps, Pumping and Special Engines. 6 hours lectures with laboratory and design work. Taken together count as a major for the degree of A.M.

MECHANICAL ENGINEERING 17, 18, 19, 20, 21, 24, 28, AND 50—Laboratory, Machinery and Mechanism, Heat and its applications, Motors other than Steam, Dynamics of Motors, Heat and Steam Engineering Laboratory, Steam Engine Design and Advanced Drawing.

6 hours lectures with laboratory and design work. Taken together count as a major for the degree of A.M.

MECHANICAL ENGINEERING 40, 51—Special problems and original investigations in advanced Mechanical Engineering with conferences, laboratory work, and design as required. Pre-requisite: all the courses offered in the department of Mechanical Engineering. Major for the degree of Ph.D.

METALLURGY 1, 2, 3, AND 6—Furnace, Fuels, and Metallurgy of Iron. 4 hours, and laboratory work. Counts as a minor for the degree of A.M.

For the details of this and following courses see circular of the courses in Mining and Metallurgy, which will be sent on application.

METALLURGY 4, 5, AND 6—Metallurgy of Non-ferrous Metals. 4 hours, and laboratory work. Counts as a minor for the degree of A.M.

METALLURGY 7—Advanced Course in Calorimetry. Determination of practical and theoretical values of various combustibles. Major or minor for A.M. or Ph.D.

METALLURGY 8—Advanced Course in Pyrometry. Determination of the temperatures of metallurgical and other high-temperature operations, *e. g.*, of the Bessemer converter for steel and for copper, the open-hearth steel furnace, the iron blast furnace, the copper-smelting cupola furnace, steam-boiler fires, etc. Major or minor for A.M. or Ph.D.

METALLURGY 9—Microscopic study of Iron, Steel, and other Metals. Preparation and microscopic examination of specimens. Major or minor for A.M. or Ph.D.

METALLURGY 10—The Heat Treatment of Steel and other Metals, with determination of the resultant effects on the physical properties. Major or minor for A.M. or Ph.D.

METALLURGY 11—The Formation-points, Melting-points, and Specific Heat of Slags, their density and viscosity when molten, and the phenomena of crusting. Major or minor for A.M. or Ph.D.

METALLURGY 12—The Influence of Strain upon the Properties of Metals. Major or minor for A.M. or Ph.D.

METALLURGY 13—The Chemistry of Roasting Processes, including the expulsion of arsenic and antimony. Major or minor for A.M. or Ph.D.

METALLURGY 14—The Chemistry of Iron Blast Furnace. Major or minor for A.M. or Ph.D.

METALLURGY 15—The Chemistry of Basic Dephosphorizing Processes. Major or minor for A.M. or Ph.D.

METALLURGY 16—Search for New and Useful Alloys. Major or minor for A.M. or Ph.D.

METALLURGY 17—Fire-brick and other Refractory Materials, their resistance to heat and to corrosion. Major or minor for A.M. or Ph.D.

METALLURGY 18—Electrolytic Refining and Depositing Processes. Major or minor for A.M. or Ph.D.

METALLURGY 19—Wet Processes for Extracting Gold, Silver, and Copper. Major or minor for A.M. or Ph.D.

MINING **3, 4,** AND **5**—Mining and Ore Dressing. 4 hours, with laboratory work and reading as required. Open to students who have taken Mining **1, 2,** and **2a.** Count together as a minor for the degree of A.M.

For details of this and following courses see circular of courses in Mining and Metallurgy, which will be sent on application.

MINING **2a, 6, 9,** AND **10**—Mining Engineering. 3 hours lectures and reading as required. Open to students who have taken Mining 1, 2, and 3. Count together as a minor for the degree of A.M.

MINING **16**—Examination of Coal-washing Plant or Ore-dressing Plant. 4 to 6 weeks in the field, with laboratory work and conferences as required. Open to students who have taken Mining 4 and 5. Minor for the degree of A.M.

MINING **17**—Examination of a Mineral Property or a Mine. 4 to 6 weeks devoted to field and underground work in the summer school of practical mining, with conferences at the convenience of the professor. Open to students who have taken all the courses in Mining. Minor for the degree of A.M.

MINING **18**—Economic Studies in Mining. Studies of existing conditions affecting the production and cost of some mineral or metal, as, for example, anthracite coal, copper, or gold. Open to students who have taken all the courses in Mining. Major or minor for the degree of A.M.

MINING **7, 7a,** AND **8**—Design of Mine Plant. 3 hours, and 5 afternoons draughting-room work. Open to students who have taken Civil Engineering 5, and Mining 1, 2, and 3. Count together as a major for the degree of A.M.

MINING **4, 5, 7a,** AND **8,** with 1 hour conference additional, first half-year—Design of Ore-dressing Works. 3 hours, and 5 afternoons laboratory and draughting-room work. Open to students who have taken Civil Engineering 5. Count together as a major for the degree of A.M.

MINING **1, 2, 2a, 3, 4, 5, 6, 7, 7a, 8, 9, 10,** AND **11,** being all the undergraduate courses in the department of Mining, count together as a major and one minor for the degree of A.M.

MINING **12**—Methods of Mining. Critical study of methods used in some mining region, or for a certain class of deposits; output per man, amount of timber and explosive required, and other details affecting cost. Study of conditions as determining choice of methods. Determination of loss of mineral in mining. Accidents to men. Open to

students who have taken all the courses in Mining. Major for the degree of A.M. or Ph.D.

MINING 13—Mining Plant. Critical study of rock drilling, or coal cutting, or hoisting, or haulage, or ventilating plant at some mine or mines. Determination of efficiency and conditions affecting same. Open to students who have taken Mining 7 and 8. Major for the degree of A.M. or Ph.D.

MINING 14—Deep Mining. Study of Problems of deep mining, vertical versus inclined shafts, hoisting and pumping from great depths, temperature and ventilation, efficiency of labor, and rock pressure as affecting methods of mining and timbering. Open to students who have taken all the courses in Mining. Major for the degree of A.M. or Ph.D.

MINING 15—Ore Dressing. Critical study of some detail of the ordinary dressing methods, crushing, or screening, or classification, or jigging, or slime treatment, or dry concentration, or magnetic separation, or milling of gold or silver ores, or mechanical preparation of coal. Determination of efficiency, and of conditions essential to success. Open to students who have taken Mining 4 and 5. Major for the degree of A.M. or PhD.

FEES AND EXPENSES

Each student, on first entering Columbia University, is required to pay (or to have paid before his fall entrance examination) a matriculation fee of five dollars ($5). A late registration fee of five dollars ($5) will also be required (*a*) of all students previously members of the University who do not *register* on or before September 22, 1903, and (*b*) of all new students who do not *register* on or before September 23, 1903. If an examination for entrance is required, such fee must be paid by the applicant for admission before examination; and in case the examination is held at a time not appointed in previous public announcements, an additional fee of five dollars ($5) is required.

In the case of an applicant who completes his examination for admission at the appointed entrance examinations of successive years, but one matriculation fee of five dollars ($5) is required. (But see above).

The College Entrance Examination Board makes a charge of five dollars ($5) for each series of examinations taken by a candidate under its auspices.

Each student is required to pay an annual gymnasium fee of seven dollars ($7). This entitles the student to a locker and to the free use of the gymnasium and the baths, including all necessary laundry service.

The annual fee of each candidate for a professional degree in Applied Science is two hundred dollars ($200), payable in two equal instalments on or before the last Saturday of October and on or before the third Saturday in February of each year.

Special students are charged at the rate of twenty dollars ($20) for each hour of attendance upon lectures or recitations with a maximum

fee of two hundred dollars ($200). All fees amounting to less than one hundred dollars ($100) must be paid on or before the last Saturday in October. For the charges for laboratory work done by special students see page 25.

To insure the prompt return in good order of tools, of keys to lockers, and to drawing tables, and to cover material consumed in the mechanical laboratories and shops, and injury to machinery therein, a deposit of ten dollars ($10) is required. Students making a deposit for chemical apparatus, as provided on page 26, are not required to make this deposit. Students not making this deposit, nor a deposit for apparatus, will deposit one dollar ($1) for each key to a locker or drawing table.

There is a coat-room for those students who do not care to have lockers.

Every student admitted to an extra or special examination, in anticipation of the time regularly appointed, or in consequence of failure to attend, or to pass satisfactorily at any entrance, intermediate, or concluding annual examination, or any other regular examination throughout the course, is required to pay a fee of five dollars ($5) *before being admitted* to such examinations. See By-Laws, section 12, page 13.

Every candidate for the degree of Engineer of Mines, or Metallurgical Engineer, or Civil Engineer, or Electrical Engineer, or Mechanical Engineer, or Bachelor of Science, or Master of Arts, is required to pay a fee of twenty-five dollars ($25) before being admitted to the final examinations.

Every candidate for the degree of Doctor of Philosophy is required to pay a fee of thirty-five dollars ($35) before being admitted to the examinations for such degree.

The necessary expenditures of which intending students should be cognizant are:

(*a*)	Board, including room-rent, fire and light, and washing, a week, from	$7.50 to $12
(*b*)	Matriculation fee (once only)	5
(*c*)	Annual gymnasium fee	7
(*d*)	Annual tuition fee for candidates for a professional degree	200
	For candidates for A.M. or Ph.D. (only)	150
(*e*)	Extra fee, for examinations at unusual times	5
(*f*)	Deposit to insure return of keys, etc.	10
	Or for each key to a locker or drawing table	1
(*g*)	Text-books for the first class, about	15
	For the second class, about	30
	For the third class	25 to 50
	For the fourth class, about	20
(*h*)	Drawing materials for the first and second classes, each	15 to 25
	For each of the other classes	5 to 10

(*i*)	Chemical and assay apparatus for laboratory courses, for each year	$20 to $60
(*j*)	During the vacations at the close of the first, second, and third years, travelling and board for summer class in field surveying for students in the courses of Mining Engineering, Civil Engineering, Sanitary Engineering, and Metallurgy	68 to 105
(*k*)	During the vacation at the close of the third year, travelling and board for summer class in practical mining for students in the courses of Mining Engineering and Metallurgy	75 to 125
(*l*)	During the vacation at the close of the third year, travelling and board for summer class in practical geodesy for students in the courses of Civil Engineering and Sanitary Engineering	68 to 105
(*m*)	During the vacation at the close of the third year, travelling and board for summer class in field geology for students in the courses of Mining Engineering and Metallurgy	15 to 20
(*n*)	Fees for the Summer Courses in Surveying:	
	Civil Engineering **15**	25
	Civil Engineering **15**. Students with advanced standing, for each survey	7
	Civil Engineering **16**	15
	Civil Engineering **16**. Students with advanced standing, for each survey	5
	Civil Engineering **16a**	5
	Civil Engineering **17**	10
	Field Laboratory Course in Geodesy	20
(*o*)	Candidates for admission to advanced standing, who attend the summer school in practical mining	50
(*p*)	Graduation fee for undergraduate students (final examination)	25

The fees required of Graduates and Special Students attending the School, but *not candidates for a degree*, are as follows

(*a*)	Matriculation fee	$5
(*b*)	Gymnasium fee	7
(*c*)	Extra fee, for examinations at unusual times	5

Should the amount of fees, exclusive of the matriculation fee, payable by any student, not exceed one hundred dollars ($100), the entire amount is payable on or before the fourth Saturday in October, or at the matriculation of the student.

The following are the laboratory fees required of special students:

DEPARTMENT	UNIT OF TIME	RATE
Chemistry	Year	$50 for use of laboratories, or any of them
Engineering		
Civil Engineering	Two weeks	Course **11.** Cement Testing laboratory, $15
	One month	Course **5.** Laboratory for testing materials, $30
Electrical Engineering	Year	Course **11,** $50; Course **10** or **12,** $40; Course **5** (laboratory portion) or **27,** $15; Course **28,** $10
Mechanical Engineering	Year	$50 for use, by non-candidates, of laboratories, or any of them
Metallurgy	Year	Per course: $100 for Courses **6, 9, 10, 14, 15.** $75 for Course **8.** $50 for Courses **11, 12, 13, 16, 17, 18, 19.** $25 for Course **6a.** $20 for Course **7**
Mining	Year	Course **5,** $50
Physics	Year	$25 for use of laboratories by those not taking other instruction from department; $5 for special students taking other than undergraduate lecture courses

Graduates who are *candidates for degrees* must pay the matriculation fee of five dollars ($5) and an annual tuition fee of one hundred and fifty dollars ($150), irrespective of the number of hours of weekly attendance, for the degree of Master of Arts and the degree of Doctor of Philosophy; for other degrees, two hundred dollars ($200), and for examination:

For degree of Doctor of Philosophy	$35
For other degrees	25

Apparatus Supplies

1. Students may purchase apparatus of any of the dealers in the city.

2. To avoid inconvenience and expense to the students, and to secure a proper selection, the University undertakes, at considerable trouble and expense, to lend apparatus on the following conditions:

(*a*) Each student engaged in chemical or assay laboratory work, who draws apparatus, must make with the Bursar deposits as follows, which will be credited to him:

Students taking general chemistry only	$20
Students taking laboratory work in physical chemistry only,	10
Students taking first-year work in qualitative analysis . .	20
Students in metallurgy desiring chemical apparatus . .	20
Students taking other chemical or assay laboratory work .	40

In case of excessive draughts of apparatus an additional deposit may be required.

(*b*) Each student shall be entitled, on presenting his receipt at the apparatus room, to draw the regular set of apparatus for qualitative analysis, quantitative analysis, organic analysis, elementary chemistry or assaying, on account of his deposit, and from time to time to obtain ordinary articles that he may need, which will be charged to him. At the end of the year he will be credited with those articles which he returns in good order, and the value of those which he has injured or broken will be deducted from his deposit.

(*c*) The apparatus room will be open for issuing apparatus every day at convenient hours.

(*d*) No charge is made for ordinary chemicals.

(*e*) Students who furnish their own apparatus are required to make a deposit of ten dollars ($10) to cover the use of reagent bottles, keys, and the like.

Dormitory

It is hoped that before the end of September, 1903, a well-equipped private dormitory in the immediate vicinity of the University will be ready to receive students of the Schools of Applied Science. Full information with regard to it may be had after July 1, 1903, upon application to the Secretary of the University.

FELLOWSHIPS

University Fellowships

Eighteen fellowships, of the value of $650 each, known as "University Fellowships," are awarded by the Council to those applicants who give evidence of special fitness to pursue courses of higher study and original investigation, under the Faculties of Political Science, Philosophy, Pure Science, and Applied Science, the competition to be open to graduates of all colleges and scientific schools.

Application should be made prior to March 1, in writing, on blanks that will be furnished for the purpose, and addressed to the President of Columbia University.

No holder of a fellowship will be permitted to pursue a professional or technical course of study during his term. With the written ap-

proval of the President, but not otherwise, he may give instruction or assistance in any department of the University.

For further details as to the award of the University Fellowships, see the Announcement of the Faculties of Political Science, Philosophy, and Pure Science, in which the regulations of the University Council are printed in full.

Tyndall and Barnard Fellowships

The Tyndall Fellowship for the Encouragement of Research in Physics, endowed by Professor John Tyndall, and of an annual value of $648, and the Barnard Fellowship for Encouraging Scientific Research, endowed by the bequest of the late President Barnard, annual value $500, are awarded annually by the University Council under the following conditions: The Tyndall Fellowship is available for one or more American pupils who may have shown decided talent in physics, and preferably such as shall express the determination to devote their lives to the advancement of theoretic science and original investigations in that department of learning, and is awarded either to a graduate of the University or to a student in it (not necessarily a candidate for a degree) upon the recommendation of the head of the department of Physics. The Barnard Fellowship is awarded upon the joint recommendation of the Faculties of Columbia College, Applied Science, and Pure Science to a graduate of any one of them who, having shown decided aptness for physical investigation, is disposed to devote himself thereto for some years continuously. The recommendation must in each case be made to the President on or before April 1. The appointment is for the term of one year, but the incumbent shall be eligible to reappointment.

It is the duty of a John Tyndall or Barnard Fellow to devote himself faithfully to the investigation of some subject in physical science at this University, or at some other in this country or abroad, under the supervision of some known physicist approved by the President and the head of the department of Physics. He shall make a report, certified to by the physicist superintending and directing him, quarterly to the President, giving an account of the work in which he has been engaged during the three months preceding.

SCHOLARSHIPS

Thirty-five scholarships of the annual value of $200 each are available annually for award to meritorious candidates for professional degrees in Applied Science and Architecture, in good academic standing, and standing in need of pecuniary aid:

Benefactor Scholarships.—In recognition of the liberal gifts for the purchase of the site on Morningside Heights which have been received from J. Pierpont Morgan, Cornelius Vanderbilt, D. Willis James, Morris K. Jesup, Samuel D. Babcock, Oswald Ottendorfer, and others, the Trustees have established a number of scholarships, twenty-seven

of which are open to students in the Schools under the Faculty of Applied Science, as follows: seven Morgan, seven Vanderbilt, ten James, one Jesup, one Babcock, and one Ottendorfer. These scholarships may be awarded to students who have been in the University for at least one year, and whose record for ability and scholarship gives evidence of special fitness for the course of study which they propose to pursue.

Faculty Scholarships.—In addition to the above, eight Faculty scholarships may be awarded to members of any class whose record for ability and scholarship, obtained either before or after matriculation, gives evidence of special fitness for the course of study which they propose to pursue.

Lawrence Scholarship.—Through the generosity of Mr. Benjamin B. Lawrence, of the Class of 1878, Applied Science, a scholarship in Mining Engineering of the value of $200 is available for a deserving student in the course of Mining Engineering.

Applications for the above scholarships should be made in writing, on blanks which will be furnished for the purpose by the Secretary of the University, and should be addressed to him. Applications should be made not later than May 1, as any received later than this may fail to receive consideration.

The award of scholarships will be made not later than July 1 by the Committee on Administration. Scholarships not allotted at this time, or becoming vacant, shall be filled by the Committee at its discretion.

One half the annual value of the scholarships will be paid at the opening of the academic year, one half at the beginning of the second half-year (see page 11, last paragraph). Scholars will be required to pay all of the fees established for matriculation, use of gymnasium, tuition, and graduation.

The holders of scholarships will be held liable to perform service as proctors at the autumn entrance examinations, and at the semi-annual and concluding examinations, without fee. Students will not be called upon for service at times that interfere with their own academic work. Due notice of their assignments will be sent to them.

Scholarships granted in the first year of a student's connection with the University shall be for a half-year only, and shall be continued to those candidates only who have maintained a satisfactory academic standing during that period. Students already holding scholarships in any year must make application in the regular form if they desire to be considered for the succeeding year. No student already holding a scholarship can be considered as a candidate for a second one in that same year.

PRIZES

Barnard Medal

A gold medal established by the provisions of the will of President Barnard and endowed by him, known as the "Barnard Medal for

Meritorious Service to Science," is awarded at Commencement at the close of every quinquennial period dating from the 17th day of July, 1889, to such person, if any, whether a citizen of the United States or of any other country, as shall within the five years next preceding have made such discovery in physical or astronomical science, or such novel application of science to purposes beneficial to the human race, as in the judgment of the National Academy of Sciences of the United States shall be esteemed most worthy of such honor.

Illig Medals

A bequest of $2000 left by William C. Illig, E.M., '82, provides for the annual award of Scholarship medals at Commencement to the student or students in the graduating class of one of the Schools of Applied Science, who shall, in the judgment of the Faculty, have merited the same by commendable proficiency in their regular studies.

COMMITTEE ON EMPLOYMENT FOR STUDENTS

It is the design of the Committee on Employment for Students to put students desiring to work their way through the different departments of the University, especially those coming from elsewhere than New York or the immediate vicinity, in the way of earning enough for their partial or complete support, or, if possible, to extend assistance to them in other ways, while they are pursuing their studies here. It is believed that many opportunities may be offered to students of this class if the fact of their desire to obtain employment is made known. Some of the openings likely to be available are: private tutoring, translating, copying of various sorts, teaching in evening schools, travelling companions, stenography, and type-writing. All communications should be addressed to the Secretary of the Committee, Room 213, Library.

As the result of long experience, the Employment Committee advises Medical and Engineering Students not to undertake outside work of any kind during the academic year. The demands of these courses in lectures and laboratory work are so exacting and inflexible as to make additional responsibilities a greater burden than can be wisely assumed. It would even be better for such students to withdraw from the University for a year in order to earn the money necessary to enable them to give undivided attention to their work while in attendance.

While much work is found for students, each year, preference is naturally given in case of a choice of applicants for a position to those who have spent at least a portion of a year at Columbia, and thus have become personally known to members of this Committee or to other officers. No prospective student should come to Columbia depending entirely or even largely upon the assistance of the Committee, but should be prepared to meet at least the expenses of the first half-year —say two hundred and fifty dollars.

All the heads of clinics in the Medical School have consented to give advice without charge to students who present cards of introduction from the Committee. Such visitors are received as a general rule during office hours at private offices. This insures to students who need it the best medical advice in the city.

MEDICAL VISITOR

For the benefit of those members of the University who are without family physicians in New York City the Trustees have designated a Medical Visitor of the University, whose duties are to render medical assistance to such officers and students as may desire it, either at their homes or elsewhere, at a remuneration to be arranged between himself and individual patients. The Medical Visitor is Dr. D. S. D. Jessup, whose office is at No. 305 West Eightieth Street (telephone 960 Riverside). His office hours are from 5 to 6 P.M. daily, or by appointment.

LIBRARY

The Library is open to all officers, students, and graduates, for borrowing and reference, daily, except Sundays, Good-Friday, Fourth of July, Thanksgiving Day, and Christmas Day, throughout the year, including all other holidays and vacations.

It contains over 335,000 volumes, and is rapidly growing. It has full sets of nearly all important journals, transactions, and official reports in mining, metallurgy, geology, chemistry, physics, mathematics, and the other pure and applied sciences. More than 3000 serials are regularly received. All important works in pure and applied science are usually purchased as they appear.

GYMNASIUM

The Gymnasium is open daily during the academic year, except Sundays and holidays, from 9.30 A.M. to 7 P.M., Saturdays to 6 P.M. It is closed on Thanksgiving Day, Christmas Day, New Year's Day, and Good-Friday. On all other holidays it is open from 2 to 6 P.M.

The gymnasium fee of $7, required of all students in Applied Science, covers the free use of the Gymnasium, a locker, and the baths, and includes all necessary laundry service.

Every student is entitled to a physical examination by the Director. His physical measurements will be recorded; his strength tested; his heart, lungs, eyes, and ears examined; and his general health inquired into. On the basis of this examination, advice will be given as to the kind and the amount of exercise best adapted to his needs. This examination is required of all students taking the prescribed work, both at the beginning and at the end of the course.

Two hours a week of work in the Gymnasium is prescribed for all

members of the two lower classes in the College and the Schools of Applied Science, except special students, and students holding degrees from other colleges. The work prescribed for these classes has been arranged with a view to instructing students in the use of the apparatus provided and giving them the largest amount of the most suitable exercise. The movements are arranged in the most approved physiological order and are designed to exercise every part of the body without exhaustion. In addition, each student in these prescribed courses is given, without extra charge, an opportunity to learn the elements of the four principal arts of self-preservation—boxing, fencing, wrestling, and swimming. The prescribed work consists of (1) carefully arranged movements in classes, with musical accompaniment, free-hand exercises, and drills with dumb-bells, French wands, Indian clubs, iron wands, and chest weights; (2) progressive exercises, in graded squads, on the various heavy apparatus, such as horizontal, vaulting, and parallel bars, flying and swinging rings, German horses and bucks, ladders, tumbling, and the like; (3) gymnastic games that develop agility, coördination, and ability to think and act quickly. Students are marked upon the basis of attendance, effort, and knowledge of the subjects taught.

Optional classes, open to every member of the University, for exercises similar to those in the prescribed courses, are held every afternoon except Saturday, as follows: Monday, Wednesday, and Friday, mass exercises in light gymnastics; Tuesday and Thursday, squad exercises in elementary and advanced heavy gymnastics.

Instructors are on the floor at all times when the Gymnasium is open.

PUBLIC WORSHIP

Services are held in Earl Hall every week-day except Saturday, at 9.10 o'clock. The service lasts fifteen minutes and consists of singing, reading of the Scriptures, prayers, and generally an address by the Chaplain or by some other officer of the University. All officers and students of the University are invited to be present.

Academic Calendar

1903—Sept. 14—Monday	Entrance examinations and examinations for deficient and debarred students begin
Sept. 16—Wednesday	Registration begins
Sept. 22—Tuesday	Registration ceases for students previously matriculated. Later applications received only upon payment of an additional fee of $5
Sept. 23—Wednesday	First half-year, 150th year, begins. Registration ceases for students matriculating for the first time. Later applications received only upon payment of an additional fee of $5
Oct. 14—Wednesday	Holders of scholarships to report themselves as in residence to the Registrar
Oct. 24—Saturday	Last day for payment of first-term fees
Nov. 3—Tuesday	Election Day, holiday
Nov. 26—Thursday to Nov. 28—Saturday	Inclusive, Thanksgiving Day holidays
Dec. 21—Monday to 1904—Jan. 2—Saturday	Inclusive, Christmas holidays
Jan. 4—Monday	Exercises resumed
Jan. 20—Wednesday	Mid-year examinations begin
Jan. 30—Saturday	First half-year ends
Feb. 1—Monday	Second half-year begins
Feb. 10—Wednesday	Holders of scholarships to report themselves as in residence to the Registrar
Feb. 20—Saturday	Last day for payment of second-term fees
Mar. 31—Thursday to April 4—Monday	Inclusive, Easter recess
April 2—Saturday	Last day for handing in graduation theses

May 2—Monday	Last day for filing applications for University Scholarships
May 18—Wednesday	Final examinations begin
May 30—Monday	Memorial Day, holiday
June 5—Sunday	Baccalaureate Sermon
June 6—Monday	Class Day
June 8—Wednesday	Commencement Day
June 20—Monday	Examinations of the College Entrance Examination Board begin. For dates for filing applications, see Document No. 11 issued by the Board, Sub-Station 84, New York, N. Y.
July 6—Wednesday	Fifth Summer Session opens
Aug. 17—Wednesday	Fifth Summer Session closes
Sept. 12—Monday	Last day for filing applications for September entrance examinations by candidates for admission
Sept. 19—Monday	Entrance Examinations, and examinations for deficient and debarred students, begin
Sept. 21—Wednesday	Registration begins
Sept. 27—Tuesday	Registration ceases for students previously matriculated. Later applications received only upon payment of an additional fee of $5
Sept. 28—Wednesday	First half-year, 151st year, begins. Registration ceases for students matriculating for the first time. Later applications received only upon payment of an additional fee of $5

COLUMBIA UNIVERSITY OFFERS THE FOLLOWING COURSES

In Columbia College.
A four-year course for men leading to the degree of . A.B.

In Barnard College.
A four-year course for women, leading to . . . . A.B.

In the School of Law.
A three-year course leading to . . . . . . LL.B.
Also, in combination with the Faculty of Political Science, a course leading to . . . . LL.M.

In the School of Medicine (College of Physicians and Surgeons):
A four-year course leading to . . . . . M.D.

In the School of Mines. Four-year courses:
In Mining Engineering and in Mining and Geology, each leading to . . . . E.M.
In Metallurgy, to . . . . Met.E.

In the School of Chemistry. Four-year courses:
In Analytical, Industrial, and Organic Chemistry, each leading to . . . . B.S.

In the School of Engineering. Four-year courses:
In Civil and Sanitary Engineering, each leading to . C.E.
In Electrical Engineering, to . . . . . . E.E.
In Mechanical Engineering, to . . . . . Mech.E.

In the School of Architecture, a four-year course leading to . B.S.

In Teachers College.
A four-year course leading to the degree of . . . B.S.
Two-year courses leading to the Bachelor's Diploma in Elementary Teaching, Kindergarten, Domestic Art, Domestic Science, Fine Arts, Music, and Manual Training. Graduate courses leading to the Master's Diploma and the Doctor's Diploma.

Under the Faculties of Political Science, Philosophy, and Pure Science: Graduate Courses leading to . A.M. and Ph.D.

In the Summer Session: (A) Courses accepted in partial fulfilment of the requirements for the various degrees and diplomas. (B) Practical courses in medicine at the College of Physicians and Surgeons.

In all of its Departments the University offers, in addition to the regular courses leading to the various degrees and diplomas, special courses to meet the needs of persons who wish to make a serious study of some special branch of knowledge. Admission to such courses is subject to the regulations of the several Faculties.

The first-year subjects in the Schools of Law, of Medicine, and of Architecture and the first- and the second-year subjects in the Schools of Applied Science are open, as electives, to students in the College entering not later than the beginning of the Junior year. By a judicious arrangement of their electives, such students may enter the second year in the School of Law, of Medicine, or of Architecture, or the third year in the Schools of Applied Science, at the completion of their collegiate course for the A.B. degree. It is possible, also, for students registered primarily as candidates for A.B., A.M., or Ph.D. to select courses that shall at the same time be counted towards one of the Teachers College diplomas; and, similarly, candidates for a diploma may obtain credit towards one of the non-professional degrees.

Bulletins of Information regarding any of these courses will be sent without charge on application to the Secretary of the University. Information on special points not contained in them may be had from the same source.

The complete Catalogue, issued in December of each year, is sold at 25 cents.

Fifth Series, No. 12 April 8, 1905

Columbia University Bulletin of Information

SCHOOL OF MINES

MINING ENGINEERING

METALLURGY

ANNOUNCEMENT

1905-1906

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New York, N. Y.

Columbia University
Bulletin of Information

(Issued 25 times during the Academic Year, monthly in November and December, and weekly between February and June. Entered as second-class matter at the New York, N. Y., Post Office, Dec. 22, 1900, under Act of July 16, 1894.)

These include:

1. The President's Annual Report to the Trustees.
2. The Catalogue of the University, issued in December, price 25 cents.
3. The Announcements of the several Colleges and Schools, and of certain Divisions, issued in the Spring, and relating to the work of the next year. These are made as accurate as possible, but the right is reserved to make changes in detail as circumstances require. The current number of any of these Announcements will be sent without charge upon application to the Secretary of the University.

April 1905—3500

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Jules A. Coelos, C.E. . . . . *Assistant in Civil Engineering*

Non-Resident Lectures for 1904-05.

In the Department of Mining:

M. B. Spaulding, E.M., Consulting Engineer.

R. V. Norris, E.M., Consulting Engineer, Pennsylvania Coal Companies.

H. P. Gillette, E.M., Associate Editor, Engineering News.

Charles Piez, E.M., General Manager and Chief Engineer, Link Belt Engineering Co.

J. P. Hutchins, E.M., Consulting Engineer.

Geo. C. Stone, E.M., Chief Engineer, New Jersey Zinc Co.

B. B. Lawrence, E.M., Consulting Engineer.

E. B. Durham, E.M., Engineering Department, Trenton Iron Co.

J. A. Church, E.M., Ph.D., Consulting Engineer.

J. A. Janeway, E.M., Engineer, John A. Roebling's Sons Co.

John B. Clayberg, LL.B., Lecturer on Mining Law, University of Michigan.

In the Department of Metallurgy:

George C. Stone, Ph.D., Chief Engineer of the New Jersey Zinc Company.

J. Parke Channing, E.M., President, Tennessee Copper Company.

Charles Kirchhoff, Editor of the *Iron Age.*

Richard Moldenke, Ph.D., Secretary of the American Foundrymen's Association.

Edward D. Peters, M.D., Professor of Metallurgy, Harvard University.

Joseph Struthers, Ph.D., Assistant Editor, American Institute Mining Engineers.

James Douglas, LL.D., President of the Copper Queen Mining Company.

W. B. Devereux, Consulting Engineer.

GENERAL STATEMENT

COURSE IN MINING ENGINEERING

The four-years' course leading to the degree of Engineer of Mines is intended primarily to train men to undertake the development of mineral properties, and to manage mines and metallurgical works. The course necessarily is a broad one, including a wide range of studies in pure and applied science, and for this reason is frequently taken by students desiring a general scientific training.

Geological Alternative

In the fourth year students of mining have the option of omitting certain courses in Mechanical Engineering, and taking in their place certain courses in Geology. This geological option is intended for students who expect to devote themselves to field-work in economic geology, or whose professional work is likely to be in new and less developed mining regions, and for other cases in which geological training may be of prime importance.

COURSE IN METALLURGICAL ENGINEERING

The four-years' course leading to the degree of Metallurgical Engineer has much in common with the course in Mining Engineering. In this course somewhat less time is given to mechanical engineering and to mining, and more to chemistry and metallurgy.

Modifications of these Courses

Regular undergraduate students, who wish to fit themselves for special work in mining or metallurgy, may sometimes vary the regular course in the sense of substituting for certain of the prescribed studies, studies from other regular courses. There is no provision for short or partial courses in mining or metallurgy.

Graduates of colleges or scientific schools are admitted to advanced standing without examination, and are given credit in full or in part for work done elsewhere, so far as such work is substantially the equivalent of the requirements of this institution.

Graduate students may pursue mining or metallurgical studies for the degree of Master of Arts or Doctor of Philosophy, or for special study and original investigation as detailed on pages 37, 38 and 43.

Special students, not graduates, who are properly qualified by age, by special training and experience and by ability, are sometimes admitted for advanced studies or original research in mining or metallurgy, but they can rarely be admitted to the regular undergraduate courses in these subjects.

Purpose and Scope of Mining and Metallurgical Courses

The subjects most emphasized in these courses are mining, metallurgy, chemistry, geology, mineralogy, and engineering.

Metallurgy necessitates instruction in inorganic and applied chemistry, qualitative and quantitative analysis, and assaying.

Geology must carry with it preliminary training in crystallography, mineralogy, and petrography.

Engineering in all its branches demands a fundamental knowledge of mathematics, physics, mechanics, and thermodynamics. The proper design and construction of mining plants involves the study of certain branches of civil engineering, and the numerous and increasing applications of machinery to mining make it necessary to give more and more attention to the theory and practice of mechanical and electrical engineering.

As the graduate probably will be employed at first as a draughtsman or as a chemist or assayer, or as a surveyor, much time is given to work in the draughting room, in the laboratories, and in the field.

The courses are severe, and should be undertaken only by those who are well prepared physically, mentally, and by previous training to devote themselves earnestly to the work required of them.

The instruction is from text-books, and by lectures, supplemented by work in the draughting rooms, in the laboratories, and in the field, and by systematic study in the shops, in the mines, and in metallurgical establishments. In the course in Metallurgy special importance is attached to the work in the metallurgical laboratory. The summer courses in surveying, geology, mining and metallurgy constitute an important and valuable feature of the scheme of instruction.

Preliminary Course in Columbia College

By reference to the University Catalogue or to the Columbia College Announcement it will be found that a course of study of four years may be taken in the College, so constituted as to make it preliminary to the last two years of the regular courses in Mining or Metallurgical Engineering. This college course leads to the usual degree of Bachelor of Arts. It should include as electives, beginning with chemistry and physics in the Freshman year, all those subjects which constitute the first and second years of the courses in Mining or Metallurgical Engineering, so that at its completion, and after receiving the college degree, the student can pass directly into the third year of the courses leading to the professional degree.

This course is designed to afford an advanced general preparation for those who are subsequently to take the degree of Mining or Metallurgical engineer, and especially to include the necessary elements of a liberal education in language, history, and philosophy, which subjects

are necessarily omitted from the professional courses for lack of time. The combined six-years' course thus forms a complete and well-rounded training, and is strongly urged and recommended as the most advantageous preparation for a professional career.

SITUATION

Many coal, iron, and other mines, slate and stone quarries, and metallurgical works are easily accessible from New York in from one to four hours by rail. Among these are magnetic iron mines in New York, New Jersey, and Pennsylvania; hematite mines and stone quarries in the same states, and in Connecticut; anthracite and bituminous coal mines, and natural gas and oil wells in Pennsylvania, and zinc mines in New Jersey and Pennsylvania. New York and adjacent states produce each year about half the pig-iron and coal, and over forty per cent. of the total value of the mineral product of the whole country. There are within easy reach of New York City iron blast furnaces and some of the most skilfully arranged and managed steel works, iron foundries, copper smelting and refining works, lead refining works, zinc works, and electrolytic establishments in the world. New York City, moreover, is the headquarters of numerous corporations operating mines and metallurgical works in this and other countries. Within a radius of one hundred miles of New York City may be studied many phases of the best practice in mining and metallurgy in the country. By going a little farther one may reach the bituminous coal fields and the natural gas, oil, and salt regions in one direction, and the pyrite deposits, and granite and marble quarries of New York and New England in the other; while the excursions of the summer class in mining extend as far as the iron, copper, zinc, lead, silver, and gold regions of Michigan, Missouri, Montana, Colorado, and Utah.

The metropolitan situation of the school renders it possible to present, also, as parts of the regular courses in mining and metallurgy, special lectures by prominent engineers. The list of such lecturers for 1903-1904 is given on page 5.

BUILDING

The New School of Mines Building—Through the generosity of Mr. Adolph Lewisohn a new building has been provided for the School of Mines for the use of the departments of mining and metallurgy. It is hoped that this building will be ready in October, 1905. The new School of Mines building will be 145 feet long by 57 feet in width and four stories in height, with basement and sub-basement, or six floors in all. The basement and sub-basement will contain the ore dressing laboratories. The main entrance to the building is to be on the first

floor. In the center of the building on this floor, and on either side of the entrance hall will be the mining and metallurgical museums. At the north and south ends of the building will be the lecture rooms, opening out of the museums. On the second floor will be the offices of the department of mining, the mining and metallurgical department libraries, a large drafting-room for the design work of the fourth year, and one of the metallurgical laboratories. On the third floor will be the offices of the department of metallurgy, the furnace rooms, the chemical laboratory, and the research laboratories of the same department. The fourth floor will contain three large drafting-rooms and the offices of the instructors in charge.

EQUIPMENT

DEPARTMENT OF MINING

Lecture Illustrations—The lectures on mining are illustrated by 5 sets of books aggregating over 300 volumes, and containing 85,000 blue prints from negatives made for the purpose. There are a sufficient number of these books, illustrating the different courses of lectures, to allow each student the use of one or more for reference during the lectures, and for home study. These blue prints have many advantages over the usual form of lecture illustrations by lantern slides or wall diagrams. The latter are, however, used when necessary to supplement the blue prints.

Mining Library—The University library contains complete sets of the transactions of all mining, metallurgical, and engineering societies, and of the more important periodical publications on these subjects. There is also a large collection of books on mining, and all new publications of value are added as they appear. In addition, a small departmental library has been created, which is accessible to students at all times.

Mining Museum—The subject of mining is illustrated by collections, as follows: Maps of coal and metal mines of this and other countries. Working drawings, diagrams, and photographs of mine plant, and of mining and dressing machinery. Models of mines and parts of mines, and of mine plant. Mining tools: picks, shovels, hammers, drills, blasting apparatus, lamps, safety-lamps, anemometers, hand-power and machine drills. Ores and dressing products from typical works in this and other countries. Surveying instruments: geological compasses and clinometers, attraction compasses, dipping needles, hanging compasses and arcs, transits, lamp signals, rods, and apparatus for plumbing and measuring shafts.

Among the more notable exhibits are large relief models of two mines of the Cleveland-Cliffs Iron Mining Co. of Michigan, a similar

model of a typical gold mine in Colorado, and a set of three glass models and two relief models of the Copper Queen Mine in Arizona, a model of the mine workings in the Mahonoy and Shenandoah anthracite coal basins, Pennsylvania, a glass model of the mine workings on the Calumet Conglomerate of Houghton County, Michigan, a model of a standard oil-well drilling rig, and a model of the St. Joseph Lead Co.'s dressing works at Bonne Terre, Missouri.

A collection of working drawings of mine plant, and a large collection of underground photographs, taken by magnesium light, are worthy of special notice.

Mining Laboratories—Seven rooms in the basement and sub-basement of the Engineering Building are equipped as laboratories for the department of mining. These laboratories serve four purposes: 1. To illustrate the physical laws bearing on mineral separation. 2. To afford opportunity for quantitative working tests. 3. To train students in the adjustment and operation of concentrating machinery, and in the making of efficiency tests under working conditions. 4. To give advanced students and others all necessary facilities for original investigation. These laboratories serve to supplement the study of ore concentration and milling made by the student as a part of the regular work of the Summer School of Mining, and in particular afford him facilities for such study that cannot well be given him at the works.

These laboratories include:

The Laboratory for Mechanical Assays contains conveniences for quantitative work in hand picking, jigging and vanning small samples of ore, and for panning gold-bearing gravel. For small scale working tests there are a number of specially designed laboratory classifiers, laboratory jigs, laboratory slime tables, and apparatus for tests by the Elmore oil process. A small laboratory magnetic concentrator is under construction.

The Crushing and Sampling Laboratory contains appliances for crushing and sampling large and small lots of ore, including a small Gates crusher, a Krom high-speed jaw crusher and Krom high-speed rolls, a sample grinder, ball and pebble mills for fine crushing, gyratory screens, a Vezin automatic sampler, and laboratory crushers, bucking plates, hand sieves, riffle samplers, etc.

The Laboratory for Working Tests contains a small power jig, a buddle, a keeve, and other similar apparatus for working a ton or more of ore at a time.

The Laboratory of Dressing Machinery contains full-sized machines of standard types, each arranged so that the products, heads, middlings and tailings are returned at once to the same machine for

re-treatment. With a small quantity of ore each machine can thus be operated as long as may be necessary, and the student is afforded an opportunity to become familiar with the adjustments of the machine and the tests of proper and successful working. The apparatus now installed includes three Harz jigs of two, three and five compartments, a Hooper air jig, two round tables, concave and convex, a Frue vanner, a Wilfley table, and a Stein-Bilharz belt table. On the lower floors are full-sized classifiers, settlers, automatic feeders, and centrifugal pumps for supplying these machines with water and ore for continuous work.

DEPARTMENT OF METALLURGY

METALLURGICAL LECTURE ILLUSTRATIONS—There is a collection of lecture diagrams, many of them colored, illustrating the various metallurgical furnaces and appliances, and also showing graphically the sequence of operations in many metallurgical processes. In addition the lectures are illustrated by the models referred to below and by actual demonstrations, as for instance in the heat-treatment of metals, in the wet metallurgical processes, in the rolling of metals, for which purpose a small roll-train is used, and in other like ways.

METALLURGICAL MODELS AND DRAWINGS—These include models of metallurgical apparatus, furnaces, Bessemer converters, roll-trains, etc., and a large number of detailed working drawings, additions to which are constantly being made.

METALLURGICAL COLLECTION—There is especially for educational and laboratory purposes and for illustrating the lectures a collection of about 3,000 specimens of ores, slags, metals, fuels, refractory materials, and the intermediate and final products of the more important metallurgical processes. Its value is increased by labels explaining the particular principles illustrated by the individual specimens and suites.

ANALYTICAL LABORATORY—The metallurgical department has an analytical laboratory open to the students in metallurgy. While this laboratory is equipped for ordinary analytical work, it is particularly designed for use in special investigations.

THE METALLURGICAL LABORATORY serves four chief purposes: (1) To give skill in the use of the instruments of precision of the art; (2) to teach what may be called analytical metallurgy; (3) to give some acquaintance with certain of the more important metallurgical processes, furnaces, and other apparatus; (4) to give advanced students and others the means of studying metallurgical principles and processes. Of these four purposes the first two are much the most important, and on them the chief stress is laid.

The Instruments of Precision. These include especially the calorimeter, microscope, and pyrometer. Throughout most of the laboratory work the student is required to control the temperature of his operations with the Le Chatelier pyrometer. To this end enough of these instruments are provided to enable each student to have the exclusive use of one throughout his course. Among the Le Chatelier pyrometers are some fitted for industrial use and others of greater delicacy, one fitted with the Roberts-Austen autographic attachment, and another with an autographic attachment developed in this laboratory. The Roberts-Austen attachment records continuously the temperature of any three furnaces or other points under observation. There are also other pyrometers, of the Siemens calorimetric, the Mesuré and Noel (Ducretet) optical, the Le Chatelier photometric, the Wiborgh air thermometer and other types.

Next in importance comes the equipment for studying the microstructure of metals, alloys, slags, etc., a subject in which every student in the course in Metallurgy has to acquire a certain proficiency. To this end the laboratory is equipped with grinding and polishing lathes, and with microscopes especially adapted for examining and photographing the structure of opaque substances.

There are a Mahler's Berthelot calorimeter, sclerometers of different types for measuring the hardness of metals, a drop testing apparatus, ammeters and many other instruments.

Analytical Metallurgy—By this is meant the study of the principles and reactions, taken one by one, which underlie the industrial metallurgical processes, as distinguished from what may be called "applied metallurgy," or the study of those processes themselves, each taken as a whole, the form which metallurgical laboratory instruction naturally took in the earlier laboratories. Analytical metallurgy in this sense forms the chief part of the students' work in metallurgy, and, as here carried out, consists chiefly in performing many experiments, each testing or aiming to discover some one or more metallurgical principles or reactions, or the temperature and other limits and other conditions which permit a given reaction to occur. In general the student must after each experiment enunciate briefly in writing the law to which his results point, or indicate how far those results severally and collectively support or oppose a given proposition. These experiments relate chiefly to such subjects as the influence of thermal treatment on the properties and microstructure of metals and alloys, especially iron and steel, the determination of melting points and other temperatures, the relation between the composition of slags and their fusibility; the influence of fluxes; the behavior of various refractory materials at a high temperature, either alone or in contact with different slags; the temperature-limits and the reactions of roasting operations; the influence of various

bodies on the reactions which take place in roasting, in the cyanide process, in the chlorination process and in pan amalgamation: the inter-reactions of carbon and molten oxides, sulphides and silicates, etc, etc.

For this study of analytical metallurgy, besides the instruments of precision already described, the laboratory is equipped with special furnaces, in large part designed for this department, heated by gas or by electric resistance, and so arranged that any predetermined temperature, within convenient limits, can be reached and held accurately; with gas forges permitting easy inspection and control of the bodies under experiment; with a small power-driven roll-train for studying the influence of work and finishing temperature on the properties of metals; apparatus for fuel-gas analysis, etc.

Applied Metallurgy—To give some acquaintance with certain individual industrial metallurgical processes and with their apparatus, the laboratory has a cupola furnace for smelting ores of copper and lead, an English cupelling furnace for cupellation, for "bringing forward" copper matte and refining black copper, a small reverberatory roasting furnace, electric furnaces and the usual crucible and muffle furnaces, a set of lixiviating and precipitating vats, a battery of amalgamating pans, kettles for desilverizing lead, a chlorinating barrel, storage batteries, voltmeters and ammeters for electrolysis, etc., etc.

There is a large assortment of alloys, and of steels and irons, which give opportunity for an extended range of investigation of their properties, besides ores, refractory materials and fluxes.

Advanced Students—While primarily designed for the use of undergraduate students, the equipment which has here been described offers to advanced students and properly equipped practitioners unusual advantages for investigating the scientific and many of the economic problems of metallurgy.

Metallurgical Library—The Metallurgical Department has in one of its rooms its own metallurgical library and reading room, containing about fifteen hundred volumes of metallurgical treatises, text books, periodicals, etc. Books may be borrowed by students of the department, under suitable restrictions. The library is open to all students, and to other persons properly introduced.

OTHER DEPARTMENTS

The Egleston Mineralogical Museum contains about 30,000 labelled specimens, and includes a systematic collection, a collection of economic minerals, important either as ores or building materials, or for use in the chemical industries, a collection illustrating the genesis and alteration of minerals, a collection illustrating the character of minerals, and small collections of artificial minerals, and one of New York City min-

erals. There are in the lecture and conference room separate student collections and a lecture collection. Several thousand unlabelled specimens are used in determinative work. The department possesses also about 1,200 sections of minerals and rocks, and 1,500 crystal models in wood and glass.

Among the collections of minerals that have been presented to the department from time to time, the largest is that of Dr. Egleston, consisting of about 5,000 specimens. Others that may be mentioned are the Gillmore collection, made in Paris under the direction of the Abbé Haüy, and presented by the late Gouverneur Kemble of West Point; a collection of Shulesburg (Wis.) stalactites, exhibited at the Sanitary Fair; a fine suite of Russian minerals, presented in 1869 by the Czar; a collection of American minerals, presented by the late Geo. T. Strong; two of the finest cerussites in the world; the Julien collection of minerals from Chesterfield, Mass.; the collection of Professor How, of King's College, Nova Scotia; and a very valuable collection made by Dr. Egleston in Japan.

In addition, a large number of gifts have been received, and these have been supplemented by careful purchasing and exchanging.

The work in general mineralogy is done in the blowpipe laboratory, which is provided with locked drawers and table room for about seventy-five students, and in the adjoining conference room, in which are the student collections of models and minerals. Opportunity is given for abundant practice in the determination of the constituents of minerals and metallurgical products.

The mineralogical lecture-room contains the duplicate lecture sets. Students in optical mineralogy have provided for their use a room with north light, and there is a large dark room thoroughly equipped for crystal measurements and monochromatic light determinations.

The Collections of the Geological Department cover economic and general geology, lithology, and palæontology. The lithological collections, embracing some thousands of specimens of typical rocks, are in the geological laboratory, on the second floor of Schermerhorn Hall, and are used in the instruction in general geology and in graduate work in petrology. There is a series for beginners, and one more complete for advanced students. The department also has several thousand thin sections of rocks and thirty-two petrographical microscopes. In an adjoining room is a collection of type fossils for use in the lectures and conferences in general geology. The collections in economic and physical geology are in the museum devoted to this branch on the floor below. A very complete series of specimens is available of the ores and local geology of North America, and to a less extent of other localities, and of coals, oils, clays, building materials, salines, and other useful minerals. Under each head the specimens are geographically arranged. The palæontological collections are in the base-

ment of Schermerhorn Hall. There is a series of rocks and type fossils, especially invertebrates, for work in stratigraphic geology, and a series of invertebrates systematically arranged to show the life histories of different races. The collections of fossil plants and vertebrates are in an adjoining room.

It is the policy of the department to make the museums less places for display than laboratories where students may study and work. The department also has a chemical laboratory for rock analysis, a room and machinery for the preparation of thin sections of rocks, and a well-equipped dark room for photography. The departmental library contains the books of the late Professor J. S. Newberry, and includes many rare volumes and pamphlets.

The University has an arrangement with the American Museum of Natural History which secures for advanced students especial privileges in its collections. As these contain among others the valuable and unique collection of Palæozoic fossils made by James Hall, the privilege is of especial consequence to students of palæontology.

The Physical Laboratories occupy nine rooms, five being devoted to general physical measurements, and four to special and advanced work. These rooms are well equipped, and have accommodation for a large number of students.

The Electrical Laboratories are provided with direct-current as well as single phase and polyphase alternating-current generators, motors, dynamos and transformers; arc and incandescent lighting apparatus; storage batteries; telegraph, telephone, and electric signalling apparatus; electrical and magnetic measuring instruments of various kinds; electrical heating and welding devices.

The Mechanical Engineering Museums include a collection illustrating the properties of new and old materials which have failed under strain, together with models of mechanisms and appliances which are used in practice, and the apparatus required by the mechanical engineer.

The Mechanical Engineering Laboratories include the notable gifts to the University which have been identified with the names of Henry R. Worthington and Edward P. Allis as memorials of their achievements in the fields of hydraulic engineering and steam engineering respectively. The Baldwin Locomotive Works also have presented a Vauclain compound locomotive, to be used for testing and experimental work. These laboratories occupy an area 210 feet long by 32 feet wide in an annex to the Engineering Building.

The Testing Laboratories of the Mechanical Engineering Department include high-grade testing machines of the Emery type, as well as the more usual Fairbanks, Riehlé, and Keep designs. New facilities are being added continually.

The Chemical Laboratories are provided with separate tables for each student, each one provided with gas, water, pressure, exhaust, and electricity, besides electric lights, and with reagents, and all the necessary apparatus, instruments, and facilities to enable the students themselves to execute the required series of qualitative and quantitative analyses. Attached to the main laboratory is a large and well-equipped balance room, containing accurate balances, and special rooms, which are equipped with the most improved apparatus for gas, water, and electrolytic analysis.

The Assay Laboratory is provided with crucible and muffle furnaces, both gas and coal, for the fire assay of ores; also with crushing, pulverizing, and sampling machinery, balance room, storeroom, and thirty-six well-equipped working desks. It also contains all the apparatus necessary for the wet assay of silver bullion and for laboratory tests of ores.

The Chemical Library in Havemeyer contains a collection of chemical books and journals, and is open from 9.30 a.m. to 5.30 p.m. during term time.

SUMMER COURSES

Summer Courses in Surveying—These courses are conducted during sixteen weeks of each summer vacation at a large farm owned by the University near Litchfield, Conn., where ample facilities are provided for all requisite operations, and where the topography is admirably adapted to the practical work of surveying. The field work of the summer courses includes numerous surveys made in squads of two men by pacing, with compass and chain, with transit and tape or telemeter, and with the plane table; levelling, contour sketching, railroad reconnaissance and location, together with such lectures, computations, and mapping as pertain to them. About six weeks' attendance is required of each class between the first and second years, and ten weeks between the second and third years. The equipment for the courses is unusually complete with engineers' and solar transits, levels, plane tables, compasses, and all accessories and smaller instruments. A corps of special assistants for each session aid the regular officers in charge of the courses.

Summer Courses in Practical Mining—The scheme of instruction includes six weeks spent in detailed study of the plant and methods of working at some mine or mines; in geological work, surface and underground; in mine surveying, and in excursions to other mines and mining regions. These summer courses are under the per-

sonal supervision of one of the Professors of Mining and the other members of the staff of the Department of Mining. The scheme of study includes shaft-sinking, drifting, stoping, timbering, underground haulage, hoisting, mine drainage, ventilation, surface plant and machinery, mine buildings, shops, houses, etc., water supply, drainage, organization, administration, and underground surveying. The students are divided into small squads, and assigned each day to a foreman, or working gang of miners, for the study of some definite subject. Each squad of students is visited several times during the day by the instructor, who supplements the explanations of the miners, and indicates subjects demanding special study and observation. Manual labor and the acquirement of manual dexterity by the student are subordinated to the development of his powers of observation, and to the careful and critical study of the work going on about him, and the recording of his observations and study in notes and sketches taken on the spot. The students' note-books are examined and criticised each evening. By thus systematizing and directing the work of the student his time is economized, and as much ground is covered in a week as would be in a month under ordinary circumstances, and the work is done more thoroughly.

These summer courses have been in operation since 1877, and have proved themselves an indispensable adjunct to the regular curriculum. They bear the same relation to the study of mining as laboratory work to the study of chemistry or physics, or clinical instruction and hospital practice to the study of medicine.

In 1901 the summer courses were held in Michigan. The detail work, occupying nearly four weeks, was done in the East and West mines of the Pittsburg and Lake Angeline Iron Company, Ishpeming. Short visits were then made to the Barnum mine, and to the surface plants of several other mines in the vicinity of Ishpeming. Finally, a week was spent in the copper district, in visits to the Quincy and Atlantic mines, the Tamarack and Calumet and Hecla surface plants, and the Quincy and Calumet and Hecla concentrating mills.

In 1902 the summer courses were held in Utah. About four weeks were occupied in studying the large property of the Daly West Mining Co., near Park City, including one week of mine surveying. During the remainder of the time visits were made to the neighboring Silver King and Ontario mines. Many of the students visited informally other mines and works of the vicinity.

In 1903 the summer courses were held in Aspen, Colorado. Four weeks were spent in making a detailed study of the methods of mining, etc., at the Mollie Gibson, Smuggler, and Durant Mines. The large ore dressing works at Aspen were also visited and a week was spent in surveying a portion of the Durant Mine.

In 1904, a gift from Mr. George Crocker made it possible to hold a joint summer school of mining with Yale, Harvard, and Massachusetts Institute of Technology. The Burleigh tunnel workings at Silver Plume, Col., were leased and each student was given a week of practical instruction in the operations of drilling and blasting. Timbering was studied in a similar manner at the Dives Pelican mine, and nine days were spent at Idaho Springs in studying milling. The remainder of the time was spent in mine sampling, and in making an underground survey. Optional trips were also taken to the gold dredges and hydraulic workings at Breckenridge, and to mines in the Cripple Creek district.

Summer Courses in Metallurgy—At least two weeks in the summer are devoted to the study of metallurgy in actual practice. The class studies at various establishments, the processes there used, the arrangement of the works, the construction of the furnaces, etc.

In 1900 one week was devoted to the metallurgy of lead, gold and silver in Colorado, and one week to the manufacture of iron and steel at Pittsburg and Johnstown. In 1901, copper, lead, gold, silver, and zinc were the subjects studied at Maurer and Newark, N. J., while iron and steel were taken up at Steelton, Pa., and Sparrow's Point, Md. In 1902 the class studied the metallurgy of lead, copper, gold and silver in the vicinity of Salt Lake City, Utah, and the metallurgy of iron and steel at Phœnixville, Pa.

In 1903 and 1904 one week was spent in visiting the metallurgical works at Denver, Colorado City, Pueblo, and Florence, Colorado. The work in iron and steel was performed at the Carnegie Steel Co.'s works near Pittsburg in 1903, and at the works of the Pennsylvania Steel Co. and the Central Iron and Steel Co., Steelton, Pa., in 1904.

Summer Courses in Geology—In connection with the summer courses in practical mining, at least one week is devoted to practical field geology. The class is instructed in methods of field observation, locating outcrops, measuring dip and strike, keeping notes, etc., and afterwards are required to construct maps and geological sections from the observations noted. This instruction is given under the immediate supervision of the Professor of Geology.

Metallurgical and other Excursions—During the term the students are taken to various metallurgical establishments, and may visit different mines, foundries, machine shops, electrical establishments, and points of geological interest in the city and its environs. Excursions for this purpose are frequently organized by the different departments.

COURSE IN MINING ENGINEERING

First Year

First Half-Year

ALGEBRA (Mathematics 3b)—2 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

ANALYTICAL GEOMETRY (Mathematics 5)—3 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

PHYSICS (Physics 1)—3 hours. Dr. TUFTS, Dr. DAY, Dr. DAVIS, and Mr. PEGRAM

CHEMISTRY (Chemistry 1)—4 hours. Professor CHANDLER, Dr. LAUDY, Mr. TUCKER, and Mr. NEISH

QUALITATIVE ANALYSIS (Chemistry 7)—2 hours, and 4 afternoons and Saturdays alternate weeks laboratory. Dr. WELLS and assistants.

MINERALOGY (Mineralogy 12)—3 hours, and 4 afternoons alternate weeks laboratory. Professor MOSES, Professor LUQUER, and Dr. ROGERS

SURVEYING (Civil Engineering 1)—1 hour. Professor LOVELL and Mr. DERLETH

DRAWING (Mechanical Engineering 1)—1 afternoon draughting-room. Professor MAYER and Mr. MILLER

Second Half-Year

SPHERICAL TRIGONOMETRY (Mathematics 3a)—2 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

ANALYTICAL GEOMETRY (Mathematics 5)—3 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

PHYSICS (Physics 1)—3 hours. Dr. TUFTS, Dr. DAY, Dr. DAVIS, and Mr. PEGRAM

CHEMISTRY (Chemistry 1)—4 hours. Professor CHANDLER, Dr. LAUDY, Mr. TUCKER, and Mr. NEISH

QUALITATIVE ANALYSIS (Chemistry 7)—2 hours, and 4 afternoons and Saturdays alternate weeks laboratory. Dr. WELLS and assistants

MINERALOGY (Mineralogy 12)—3 hours, and 4 afternoons alternate weeks laboratory. Professor MOSES, Professor LUQUER, and Dr. ROGERS

SURVEYING (Civil Engineering 1)—1 hour. Professor LOVELL and Mr. DERLETH

DRAWING (Mechanical Engineering 1)—1 afternoon draughting-room. Professor MAYER and Mr. MILLER

Summer Vacation

SURVEYING (Civil Engineering 15)—5 weeks field-work. Professor LOVELL and assistants.

See pages 29-44 for departmental statements with details of the above courses

Second Year

First Half-Year

Calculus (Mathematics 6)—3 hours. Professors Van Amringe, Fiske, Maclay, and Keyser

Elementary Mechanics (Mechanics 21)—3 hours. Dr. Wills.

Physical Laboratory (Physics 3)—4 hours. Professor Parker

Industrial Chemistry (Chemistry 24)—3 hours. Professor Chandler and Dr. Laudy

Railroad Surveying (Civil Engineering 14a)—2 hours. Professor Lovell

Elements of Electrical Engineering (Electrical Engineering 37)—2 hours. Mr. Townsend

Geology (Geology 2)—3 hours. Professor Kemp

Descriptive Geometry and Drawing (Mechanical Engineering 1 and 2)—2 hours, and 3 afternoons draughting-room. Professor Mayer and Mr. Harrington

Second Half-Year

Calculus (Mathematics 6)—3 hours. Professors Van Amringe, Fiske, Maclay, and Keyser

Analytical Mechanics (Mechanics 1)—3 hours. Professor Woodward

Industrial Chemistry (Chemistry 24)—3 hours. Professor Chandler and Dr. Laudy

Geology (Geology 2)—3 hours. Professor Kemp and Professor Grabau

Elements of the Dynamo (Electrical Engineering 9)—1 hour. Professor Crocker

Quantitative Analysis (Chemistry 12)—3 hours, and 17½ hours laboratory. Professor Miller, Dr. Joüet, and Dr. Sherman

Summer Vacation

Surveying (Civil Engineering 16)—5 weeks field-work. Professor Lovell and assistants

Railroad Surveying (Civil Engineering 17)—4 weeks field-work. Professor Lovell and assistants.

See pages 29-44 for departmental statements with details of the above courses

Third Year

First Half-Year

ANALYTICAL MECHANICS (Mechanics 1)—3 hours. Professor WOODWARD

ECONOMIC GEOLOGY (Geology 3)—3 hours. Professor KEMP

RESISTANCE OF MATERIALS (Civil Engineering 5)—3 hours. Professor BURR

ENGINEERING OF POWER PLANTS (Mechanical Engineering 111)—1 hour. Dr. LUCKE

EXCAVATION AND TUNNELING (Mining 1)—3 hours. Professor PEELE

METALLURGY OF COPPER (Metallurgy 4)—2 hours. Dr. BOLLES.

DESIGN, PROBLEMS, AND WORK IN TESTING LABORATORY (Civil Engineering 5)—2 afternoons. Professor BURR, Mr. FALK, Mr. YATES, and Mr. DERLETH

ASSAYING (Chemistry 17)—2 hours, and 9 hours laboratory. Professor MILLER and Mr. HALL

Second Half-Year

ECONOMIC GEOLOGY (Geology 3)—3 hours. Professor KEMP

RESISTANCE OF MATERIALS (Civil Engineering 5)—2 hours. Professor BURR

OPTICAL MINERALOGY (Mineralogy 6)—2 afternoons laboratory for two months. Professor LUQUER

PETROGRAPHY (Geology 4)—2 afternoons laboratory work for two months. Professor KEMP and Dr. BERKEY

ELECTRICAL ENGINEERING (Electrical Engineering 5 and 105)—1 hour, and 1 afternoon laboratory. Professor CROCKER and Professor SEVER

Boring and Shaft Sinking (Mining 2)—3 hours for 3 months. Professor Peele

Mining (Mining 3)—3 hours. Professor Munroe

Mine Constructions (Mining 7a)—1 hour. Professor Peele

Mill Constructions (Mining 26)—1 hour. Mr. Kurtz

Metallurgy of Fuels (Metallurgy 1)—2 hours in February and March. Professor Stoughton

Metallurgy of Lead, etc. (Metallurgy 5a)—2 hours in April and May. Dr. Campbell

Graphic Statics (Civil Engineering 6)—1 hour. Mr. Yates.

Design, Problems, and Work in Testing Laboratory (Civil Engineering 5 and 6)—Afternoon work. Professor Burr, Mr. Falk, Mr. Yates, and Mr. Derleth

Experimental Mechanical Engineering (Mechanical Engineering 114 in part)—1 hour. Dr. Lucke

Experimental Mechanical Engineering Laboratory (Mechanical Engineering 115 in part)—1 afternoon. Dr. Lucke

Summer Vacation

Practical Mining (Mining 11)—6 weeks. Professor Peele and Mr. Kurtz

Practical Metallurgy (Metallurgy 20)—1 week. Dr. Campbell or Dr. Bolles and assistants

Field Geology (Geology 13)—1 week. Professor Kemp and Professor Grabau

Fourth Year

First Half-Year

THERMODYNAMICS (Mechanics 20)—2 hours. Dr. WILLS

STEAM ENGINE AND ITS ACCESSORIES (Mechanical Engineering 12)—2 hours. Professor HUTTON

HEAT AND ITS APPLICATIONS (Mechanical Engineering 19)—3 hours. Professor HUTTON

HYDRAULICS (Civil Engineering 12)—2 hours lectures with problem work. Mr. BLACK

ORE DRESSING (Mining 4)—2 hours. Professor MUNROE

MINE PLANT (Mining 7)—3 hours. Professor PEELE

MINE SURVEYING (Mining 9)—1 hour for three months. Professor MUNROE

MINE ADMINISTRATION (Mining 10)—1 hour. Professor MUNROE and Mr. KURTZ

METALLURGY OF IRON AND STEEL (Metallurgy 2)—3 hours for one month. Professor STOUGHTON

METALLURGY OF SILVER, GOLD, ETC. (Metallurgy 5b)—3 hours for three months. Dr. CAMPBELL and Dr. BOLLES

DESIGN OF MINE PLANT (Mining 8)—5 afternoons per week. Professor PEELE and Mr. KURTZ

PROJECT IN MINING (Mining 25)—Professor PEELE

METALLURGICAL LABORATORY (Metallurgy 6a)—10 afternoons. All officers

Second Half-Year

STEAM-BOILER AND ITS ACCESSORIES (Mechanical Engineering 13)—2 hours. Professor HUTTON

MOTORS (Mechanical Engineering 20)—1 hour. Professor HUTTON

DYNAMICS OF MOTORS (Mechanical Engineering 21)—1 hour. Professor HUTTON

GEOLOGICAL EXAMINATIONS AND SURVEYS (Geology 10)—2 hours. Professor KEMP

MINE ENGINEERING (Mining 6)—2 hours. Professor MUNROE

MINE PLANT (Mining 7)—3 hours. Professor PEELE

ORE DRESSING (Mining 4)—2 hours. Professor MUNROE

MINE ADMINISTRATION (Mining 10)—1 hour. Professor MUNROE

ORE-DRESSING LABORATORY (Mining 5)—Afternoon work for three weeks. Professor MUNROE and Mr. KURTZ

PROJECT IN MINING (Mining 25)—Professor PEELE

COURSE IN MINING ENGINEERING

GEOLOGICAL ALTERNATIVE

Fourth Year

First Half-Year

(The first three years are the same as in the regular course)

PETROLOGY (Geology 6)—2 hours, and 1 afternoon laboratory. Professor KEMP

THERMODYNAMICS (Mechanics 20)—2 hours. Dr. WILLS

HEAT AND ITS APPLICATIONS (Mechanical Engineering 19)—3 hours. Professor HUTTON

HYDRAULICS (Civil Engineering 12)—2 hours lectures with problem work. Mr. BLACK

ORE DRESSING (Mining 4)—2 hours. Professor MUNROE

MINE PLANT (Mining 7)—3 hours. Professor PEELE

MINE SURVEYING (Mining 9)—1 hour for three months. Professor MUNROE

MINE ADMINISTRATION (Mining 10)—1 hour. Professor MUNROE and Mr. KURTZ

METALLURGY OF IRON AND STEEL (Metallurgy 2)—3 hours for one month. Professor STOUGHTON

METALLURGY OF SILVER, GOLD, ETC. (Metallurgy 5b)—3 hours for three months. Dr. CAMPBELL and Dr. BOLLES

PROJECT—2 afternoons and Saturdays

Second Half-Year

PETROLOGY (Geology 6)—2 hours, and 1 afternoon laboratory. Professor KEMP

PALÆONTOLOGY (Geology 16a)—1 hour and 8 hours laboratory. Professor GRABAU and assistants

GEOLOGICAL EXAMINATIONS AND SURVEYS (Geology 10)—2 hours. Professor KEMP

ORE DRESSING (Mining 4)—2 hours. Professor MUNROE

MINE ENGINEERING (Mining 6)—2 hours. Professor MUNROE

MINE PLANT (Mining 7)—3 hours. Professor PEELE

MINE ADMINISTRATION (Mining 10)—1 hour. Professor MUNROE

ORE-DRESSING LABORATORY (Mining 5)—Afternoon work for three weeks. Professor MUNROE and Mr. KURTZ

PROJECT—2 afternoons and Saturdays

See pages 29-44 for departmental statements with details of the above courses

COURSE IN METALLURGY

First Year

ALGEBRA (Mathematics 3b)—2 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

ANALYTICAL GEOMETRY (Mathematics 5)—3 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

PHYSICS (Physics 1)—3 hours. Dr. TUFTS, Dr. DAY, Dr. DAVIS, and Mr. PEGRAM

CHEMISTRY (Chemistry 1)—4 hours. Professor CHANDLER, Dr. LAUDY, Mr. TUCKER, and Mr. NEISH

QUALITATIVE ANALYSIS (Chemistry 7)—2 hours, and 4 afternoons and Saturdays alternate weeks laboratory. Dr. WELLS and assistants.

MINERALOGY (Mineralogy 12)—3 hours, and 4 afternoons alternate weeks laboratory. Professor MOSES, Professor LUQUER, and Dr. ROGERS

SURVEYING (Civil Engineering 1)—1 hour. Professor LOVELL and Mr. DERLETH

DRAWING (Mechanical Engineering 1)—The equivalent of 3 afternoons draughting-room. Professor MAYER and Mr. MILLER

Second Half-Year

SPHERICAL TRIGONOMETRY (Mathematics 3a)—2 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

ANALYTICAL GEOMETRY (Mathematics 5)—3 hours. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

PHYSICS (Physics 1)—3 hours. Dr. TUFTS, Dr. DAY, Dr. DAVIS, and Mr. PEGRAM

CHEMISTRY (Chemistry 1)—4 hours. Professor CHANDLER, Dr. LAUDY, Mr. TUCKER, and Mr. NEISH

QUALITATIVE ANALYSIS (Chemistry 7)—2 hours, and 4 afternoons and Saturdays alternate weeks laboratory. Dr. WELLS and assistants.

MINERALOGY (Mineralogy 12)—3 hours, and 4 afternoons alternate weeks laboratory. Professor MOSES, Professor LUQUER, and Dr. ROGERS.

SURVEYING (Civil Engineering 1)—1 hour. Professor LOVELL and Mr. DERLETH

DRAWING (Mechanical Engineering 1)—1 afternoon draughting-room. Professor MAYER and Mr. MILLER

Summer Vacation

SURVEYING (Civil Engineering 15)—5 weeks field-work. Professor LOVELL and assistants

See pages 29-44 for departmental statements with details of the above courses

Second Year

First Half-Year

CALCULUS (Mathematics 6)—3 hours. Professors VAN AMRINGE, FISKE, MACLAY, and KEYSER

ELEMENTARY MECHANICS (Mechanics 21)—3 hours. Dr. WILLS

PHYSICAL LABORATORY (Physics 3)—4 hours. Professor PARKER

QUANTITATIVE ANALYSIS (Chemistry 9)—4 hours, and 3 afternoons, and Saturdays laboratory. Professor MILLER and assistants

ELEMENTS OF ELECTRICAL ENGINEERING (Electrical Engineering 37)—2 hours Mr. TOWNSEND

GEOLOLGY (Geology 2)—3 hours. Professor KEMP

DRAWING (Mechanical Engineering 2)—1 afternoon draughting-room. Professor MAYER and Mr. HARRINGTON

Second Half-Year

CALCULUS (Mathematics 6)—3 hours. Professors VAN AMRINGE, FISKE, MACLAY, and KEYSER

ANALYTICAL MECHANICS (Mechanics 1)—3 hours. Professor WOODWARD

QUANTITATIVE ANALYSIS (Chemistry 9)—4 hours, and 3 afternoons and Saturdays laboratory. Professor MILLER and assistants.

ELEMENTS OF THE DYNAMO (Electrical Engineering 9)—1 hour. Professor CROCKER

OPTICAL MINERALOGY (Mineralogy 6)—2 afternoons laboratory for two months. Professor LUQUER

PETROGRAPHY (Geology 4)—2 afternoons laboratory work for two months. Professor KEMP and assistants

GEOLOGY (Geology 2)—3 hours. Professor KEMP and Professor GRABAU

METALLURGY OF IRON AND STEEL (Metallurgy 3 and 103)—4 hours. Professor STOUGHTON

DRAWING (Mechanical Engineering 2)—1 afternoon draughting-room. Professor MAYER and Mr. HARRINGTON

Summer Vacation

METALLURGY (Metallurgy 21)—3 weeks. Professor STOUGHTON.

SURVEYING (Civil Engineering 16)—5 weeks field-work. Professor LOVELL and assistants

See pages 29-44 for departmental statements with details of the above courses

Third Year

First Half-Year

ANALYTICAL MECHANICS (Mechanics 1)—3 hours. Professor WOODWARD

ASSAYING (Chemistry 17)—2 hours, and 9 hours laboratory. Professor MILLER and Mr. HALL

ECONOMIC GEOLOGY (Geology 3)—3 hours. Professor KEMP

RESISTANCE OF MATERIALS (Civil Engineering 5)—3 hours. Professor BURR

PROPERTIES OF MATERIALS (Mechanical Engineering 10 in part)—2 hours. Professor WOOLSON

METALLURGY OF COPPER (Metallurgy 4 and 104)—3 hours. Dr. BOLLES

DESIGN, PROBLEMS, AND WORK IN TESTING LABORATORY (Civil Engineering 5)—2 afternoons. Professor BURR, Mr. FALK, Mr. YATES, and Mr. DERLETH

DESCRIPTIVE GEOMETRY (Mechanical Engineering 2)—2 hours. Professor MAYER and Mr. HARRINGTON

Second Half-Year

ECONOMIC GEOLOGY (Geology 3)—3 hours. Professor KEMP

RESISTANCE OF MATERIALS (Civil Engineering 5)—2 hours. Professor BURR

ENGINEERING OF POWER PLANTS (Mechanical Engineering 11)—1 hour. Professor HUTTON

ELECTRICAL ENGINEERING (Electrical Engineering 5 and 105)—1 hour, and 1 afternoon laboratory. Professor CROCKER and Professor SEVER

THERMODYNAMICS (Mechanics 4)—3 hours. Dr. WILLS

MINING (Mining 3)—3 hours. Professor MUNROE

MINE CONSTRUCTIONS (Mining 7a)—1 hour. Professor PEELE

METALLURGY OF FUELS (Metallurgy 1 and 101)—3 hours in February and March. Professor STOUGHTON

METALLURGY OF LEAD (Metallurgy 5a and 105a)—3 hours in April and May. Dr. CAMPBELL

GRAPHIC STATICS (Civil Engineering 6)—2 hours. Mr. YATES

DESIGN, PROBLEMS, AND WORK IN TESTING LABORATORY (Civil Engineering 5 and 6)—Afternoon work. Professor BURR, Mr. FALK, Mr. YATES, and Mr. DERLETH

LABORATORY WORK (Metallurgy 6)—4 afternoons. All officers

Summer Vacation

METALLURGY (Metallurgy 20)—3 weeks. Dr. CAMPBELL or Dr. BOLLES and assistants

FIELD GEOLOGY (Geology 13)—1 week. Professor KEMP

Fourth Year

First Half-Year

HEAT AND ITS APPLICATIONS (Mechanical Engineering 19)—3 hours. Professor HUTTON.

ELECTRICAL ENGINEERING (Electrical Engineering 3)—1 hour. Professor CROCKER and Mr. ARENDT

PHYSICAL CHEMISTRY (Chemistry 4)—3 hours, and 3 hours laboratory. Professor MORGAN

COMMERCIAL ANALYSIS (Part of Chemistry 14)—2 hours, and 3 afternoons laboratory. Professor MILLER

STEAM-ENGINE AND ITS ACCESSORIES (Mechanical Engineering 12)—2 hours. Professor HUTTON

ORE DRESSING (Mining 4)—2 hours. Professor MUNROE

MINE ADMINISTRATION (Mining 10)—1 hour. Professor MUNROE and Mr. KURTZ

METALLURGY OF SILVER, GOLD, ETC. (Metallurgy 5b and 105b)—4 hours for three months. Dr. CAMPBELL and Dr. BOLLES

ALLOYS (Metallurgy 109)—3 hours for one month. Dr. CAMPBELL

THESIS (Metallurgy 30)

Second Half-Year

STEAM-BOILER AND ITS ACCESSORIES (Mechanical Engineering 13)—2 hours. Professor HUTTON

MOTORS (Mechanical Engineering 20)—1 hour. Professor HUTTON

DYNAMICS OF MOTORS (Mechanical Engineering 21)—1 hour. Professor HUTTON

ELECTRICAL ENGINEERING (Electrical Engineering 3)—1 hour. Professor CROCKER and Mr. ARENDT

PHYSICAL CHEMISTRY (Chemistry 4)—3 hours. Professor MORGAN

ORE DRESSING (Mining 4)—2 hours. Professor MUNROE

MINE ADMINISTRATION (Mining 10)—1 hour. Professor MUNROE

ORE-DRESSING LABORATORY (Mining 5)—Afternoon work for three weeks. Professor MUNROE and Mr. KURTZ

THESIS (Metallurgy 30)

See pages 29-44 for departmental statements with details of the above courses

DEPARTMENTS OF INSTRUCTION

In the following statements the numbers refer to the exercises per week. Lectures and recitations are fifty minutes in length, and the afternoon laboratory and draughting-room exercises three hours

Courses in Chemistry

1—General Inorganic Chemistry—Introduction. Laws of chemical combination, history, occurrence, preparation, and properties of the elements and their principal compounds. Text-book: Remsen's *Inorganic Chemistry, Advanced Course.* 3 lectures and 1 recitation, first year. Professor Chandler, Dr. Laudy, Mr. Tucker, and Mr. Neish

4—Physical Chemistry—A course treating of the states of aggregation, solution, and ions in analytical chemistry, thermo chemistry, chemical mechanics, and electro chemistry. 3 hours lectures and recitations during the entire fourth year, and one afternoon laboratory during first half-year. Text-books: Morgan's *Elements of Physical Chemistry,* and Ostwald's *Physico-Chemical Measurements.* Professor Morgan and Mr. Jackson

7—Qualitative Analysis—Lectures and laboratory practice. Text-book: Wells's *Inorganic Qualitative Chemical Analysis.* 2 lectures or recitations, and 5 afternoons, alternate weeks laboratory practice, first year. Dr. Wells and assistants

9—Quantitative Analysis—Text-books: Cairn's *Quantitative Analysis;* Treadwell's *Quantitative Analysis;* and Miller's *Calculations of Analytical Chemistry.* 4 hours lectures and recitations a week during the second year; laboratory practice, 4 afternoons during the second year. Professor Miller and assistants

12—Quantitative Analysis—Text-books: Cairn's *Quantitative Analysis* and Miller's *Calculations of Analytical Chemistry.* 2 lectures and 1 recitation, with laboratory practice 6 afternoons second half of the second year. Professor Miller, Dr. Joüet, and Dr. Sherman

14—Advanced Inorganic Analysis—2 lectures and 3 afternoons laboratory practice during the first half of the fourth year, for students taking the course in Metallurgy. Professor Miller

17—Assaying—Ores and metallurgical products. Text-book: Ricketts' and Miller's *Notes on Assaying.* 1 lecture, 1 recitation, and 9 hours laboratory practice, first half third year. Professor Miller and Mr. Hall

24—Industrial Chemistry, General Course—The subjects discussed are:—(1) Air: nature, sources of contamination, sewer gas, plumbing, draining, disinfection, ventilation. (2) Water: composition of natural

waters, pollution, disposal of sewage and house refuse. (3) Artificial illumination: candles, oils and lamps, petroleum, gas and its products, electric light. (4) Limes, mortars, and cements. (5) Building-stones: decay and preservation. (6) Timber and its preservation: pigments, paints, essential oils, varnishes, preserving processes. (7) Explosives: gunpowder, gun-cotton, nitro-glycerine. (8) Glass and ceramics. (9) Electro-metallurgy. (10) Photography. Text-books: Park's *Hygiene* and Wagner's *Chemical Technology.* 3 lectures, second year. Professor CHANDLER and Dr. LAUDY

Courses in Civil Engineering

1—THEORY OF SURVEYING—Pacing survey, contouring and levelling by hand-level—Construction, use, and adjustment of instruments—Farm survey—Theory of stadia measurement—Azimuth traverse—Repetition traverse—Polaris observations—Balancing survey. Lectures and recitations. 1 hour first year. Text-book: Raymond's *Plane Surveying.* Reference book: Johnson's *Theory of Surveying.* Professor LOVELL and Mr. DERLETH

5—ELASTICITY AND RESISTANCE OF THE MATERIALS OF ENGINEERING—Laws of elasticity in homogeneous materials—Coefficients of elasticity—Relations between stresses and strains—Common and exact theories of torsion and flexure—Elastic limits, working stresses, and ultimate resistances of wrought iron, cast iron, steel, alloys, timbers, building-stones, cement, concrete, and masonry—Complete treatment of simple and continuous beams—The design and construction of iron, steel, and timber columns and beams, including the design and construction of plate girders—Shafts—Cables—Fatigue of materials—Specifications. 3 hours lectures and recitations during the first half, and 2 hours during the second half, third year; with 5 hours first half-year, and 5 hours second half-year of work in the testing laboratory and of problem and design work in the draughting-room. Reference and text-book: Burr's Elasticity and Resistance of Materials. Professor BURR, Mr. FALK, Mr. YATES, and Mr. DERLETH

6—GRAPHIC STATICS—Equilibrium polygon, and polygonal frames for all systems of loads—Graphical representations of shears and moments for both non-continuous and continuous beams—Fixed and moving loads—Lines of influence—Applications to bridge and railway trusses. 1 hour lecture during the second half third year. 5 hours of problem and design work are required in the drawing academy. Mr. YATES

12—HYDRAULICS—Flow of water through orifices—Time required for discharge of canal locks and similar volumes—Weir discharge and gauging by weirs—Gauging of water for systems of irrigation—Flow through and discharge of pipes—Design of pipe systems for city water-

works—The Venturi meter—Flow in and discharge of open canals and rivers—Gauging of streams by current meters, floats, and other means—Back-water—Impulse of streams—The motion and flow of air and other gases in and through pipes and orifices. Reference book: Merriman's *Hydraulics*. 2 hours lectures during first half fourth year, with laboratory work, frequent conferences and problems. Mr. BLACK

14a—THEORY OF RAILROAD SURVEYING—Simple, compound, and reversed curves—Transition curves—Cross-section work—Earthwork computations—Office work. Lectures and practical problems. 2 hours first half second year. Reference books: Searle's *Field Engineering* and Crandall's *Transition Curve and Earthwork*. Professor LOVELL

15—SURVEYING BETWEEN THE FIRST AND SECOND YEARS—Pacing, chaining, and ranging—Farm survey—Adjustment of instruments—Angle reading by repetition—Repetition traverse—Azimuth traverse. Five weeks, daily lectures, field and office work. Professor LOVELL and assistants.

16—SURVEYING BETWEEN THE SECOND AND THIRD YEARS—Levelling—Topographical surveys with plane table and transit—City surveys—Mining claim survey—Use of solar attachment. Five weeks, daily lectures, field and office work. Professor LOVELL and assistants

17—RAILROAD SURVEYING BETWEEN THE SECOND AND THIRD YEARS—Railroad surveying—Reconnaissance—Preliminary survey—Location—Cross-sectioning—Computations—A complete survey and location of a line two to five miles long are made, with all the attendant computations requisite for placing the work under contract. Four weeks, daily lectures, field and office work. Professor LOVELL and Assistants

Courses in Electrical Engineering

3—ELECTRO-CHEMISTRY—Including electro-metallurgy; theory and applications of electrolysis and electrical heating; theory and practice of primary and secondary batteries; production, separation, and purification of metals and chemicals. 1 hour a week, fourth year. Professor CROCKER and Mr. ARENDT. Pre-requisites: Electrical Engineering 4, Chemistry 7

5—ELECTRICAL ENGINEERING—The principles of Electrical Engineering and their application to general engineering. 1 hour lecture, second half third year. Professor CROCKER. Pre-requisites: Physics 1, Electrical Engineering 9

9—ELEMENTS OF THE DYNAMO—Text-book: Crocker's *Electric Lighting*, Vol. I. 1 hour a week second half, second year. Professor CROCKER. Pre-requisite: Electrical Engineering 37

37—ELEMENTS OF ELECTRICAL ENGINEERING—General electrical principles, laws, measurements, and the introduction to their applications.

Text-book: Thompson's *Elementary Lessons in Electricity and Magnetism.* 2 hours a week, first half second year. Mr. TOWNSEND. Pre-requisite: Physics 1

105—DIRECT CURRENT LABORATORY—Short course for students in Civil, Sanitary, and Mining Engineering, Metallurgy, and Chemistry (Course B). Text-book: Sever's *Electrical Engineering Experiments, etc.* 1 afternoon laboratory work, second half third year. Professor SEVER and assistants. Pre-requisites: Physics 1 and Electrical Engineering 9

Courses in Geology

2—GENERAL GEOLOGY—First half-year physical geology, with practical work in the rock collections under the lithological part of the subject; second half-year, stratigraphical and historical geology, involving laboratory work with type fossils and collections illustrating the geology of the United States. Text-books: Scott's *Introduction to Geology;* Kemp's *Hand-book of Rocks.* 3 hours lectures, second year. Professor KEMP, Professor GRABAU, and Dr. BERKEY

3—ECONOMIC GEOLOGY—First half-year, discussion of the general features and formation of ore bodies, followed by a description of the deposits of the ores of iron, copper, lead, zinc, silver, gold, and the lesser metals, with especial reference to North America; second half-year, a description of the distribution and occurrences of coal, petroleum, natural gas, asphalt, building-stone, water supply, salines, and minor minerals. Text-book: Kemp's *Ore Deposits of the United States and Canada,* and lecture notes privately printed. 3 hours lectures and conferences, third year. Professor KEMP

4—PETROGRAPHY—A short course in the microscopic study of rocks. Follows Mineralogy 6. 2 lectures and 1 afternoon, two months of the second half third year. Professor KEMP and Dr. BERKEY

6—PETROLOGY—A discussion of the origin, microscopic structure, and mineralogical composition of the crystalline rocks, and of metamorphism. Pre-requisite: Optical Mineralogy. 2 hours lectures and 1 afternoon laboratory, fourth year. Professor KEMP

10—GEOLOGICAL EXAMINATIONS AND SURVEYS—A discussion of the methods of systematically recording and interpreting geological phenomena; and of the organization and scope of geological surveys on a larger scale. This is followed by a sketch of the history and results of state and national geological surveys in this and other countries; and of other sources of detailed information regarding local geology. 2 hours, second half fourth year. Professor KEMP

16a—PALÆONTOLOGY (FOSSIL FAUNAS)—A study of American fossil characteristic of the various geologic horizons. All the index and other

important fossils of each formation are considered. 1 lecture and 8 hours laboratory, second half fourth year. Professor Grabau and assistants

Summer Courses

13—Field Geology between the Third and Fourth Years—The summer courses in geology are held in connection with the summer course in practical mining, and at least one week is devoted to field-work. During the college year excursions are offered to points of geological interest near New York on all Saturdays and holidays of the fall and spring. Few other localities afford so extensive and so accessible exposures as the vicinity of New York. Professor Kemp

Courses in Mathematics

3b—Algebra, General Theory of Equations (Wells' *College Algebra*)—2 hours, first term of first year. Professor Keyser, Mr. Mitchell, Dr. Ling, Mr. Gray, and Mr. Hook

3a—Spherical Trigonometry (Davies' *Legendre*)—2 hours, second term of first year. Professor Keyser, Mr. Mitchell, Dr. Ling, Mr. Gray, and Mr. Hook

5—Analytical Geometry (Wentworth's)—3 hours, first year. Professor Keyser, Mr. Mitchell, Dr. Ling, Mr. Gray, and Mr. Hook

6—Differential and Integral Calculus (Osborne's)—3 hours, second year. Professors Van Amringe, Fiske, Maclay, and Keyser

Courses in Mechanical Engineering

1—Elementary Mechanical Drawing—Use of instruments, elementary projections, descriptive geometry, graphics, and stereotomy. 5 hours drawing academy in the first year, with 5 hours draughting-room, and 2 hours lectures and recitations in the first half second year. Professor Mayer and Mr. Miller

2—Specialized Engineering Drawing—Topographical and geological, charts and maps; working and isometric drawing of machinery, furnaces, and structural work. Tracing and blue printing, and shop drawings. 2 hour lectures and 5 hours draughting-room, first half second year. Professor Mayer and Mr. Harrington

10—Properties of Materials—Discussion of properties of constructive materials other than wood; rustless coatings and various methods of protecting metal work; having metal alloys. 2 hours, first half of third year. Professor Woolson

11—Engineering of Power Plants—Steam-engines and their mechanisms, rotary engines, the single-acting engine, the mechanical features

and construction of the condensing, compound, and multiple-expansion engines. 1 hour lecture with recitation, second half third year. Professor HUTTON

12—THE STEAM-ENGINE AND ITS ACCESSORIES—The Power Plant continued—Engine valve-gear, details of construction, erection and setting piping, accessories, and repairs. 2 hours lectures with recitations, first half fourth year. Professor HUTTON

13—THE STEAM-BOILER AND ITS ACCESSORIES—The Power Plant concluded—Typical forms, construction, accessories, wear and tear, repairs, tests, inspection, operation, and control. 2 hours lectures with recitations, second half fourth year. Professor HUTTON

111—ENGINEERING OF POWER PLANTS—Engines: Construction and operation, types of engines, governors, valves, valve diagrams, etc. Boilers: Construction, types, etc. Steam piping, pressure gauges, indicators and indicator diagrams, feed pumps, injectors and other auxilliary machinery, their construction and performance. Problems illustrating different parts of the course. Text-book: Pullen, *Steam Engineering*. 1 hour lecture a week first half third year. Dr. LUCKE

114—EXPERIMENTAL MECHANICAL ENGINEERING—Laboratory methods for the determination of data for calibration of instruments. Solution of mechanical engineering problems on assumed data. 1 hour, second half third year. Dr. LUCKE

115—EXPERIMENTAL MECHANICAL ENGINEERING LABORATORY—Calibration of thermometers, gauges, and indicators—Measurement of water in steam, indicated and brake horsepower, lubricating value of oils—Tests for efficiency of water wheels, steam pumps, simple steam-engine, compound engine, gas engine, air compressor and steam-boiler. 1 afternoon, second half third year. Dr. LUCKE

19—HEAT AND ITS APPLICATIONS—Fuels for motive power, combustion, transfer of heat, heating surface, generation of steam, chimneys, artificial draft, smoke prevention, use of steam in engines, super-heating; gas and air engines, combined vapor engines, ammonia and other vapor engines, air compressors, refrigerating machinery. 3 hours lectures with recitations, first half fourth year. Professor HUTTON

20—MOTORS OTHER THAN STEAM—Animal, water, wind, and wave motors; turbines. 1 hour lecture, second half fourth year. Professor HUTTON

21—DYNAMICS OF MOTORS—Work of motors, dynamometers, governors, regulators, inertia, friction, and efficiency. 1 hour lecture, second half fourth year. Professor HUTTON

Courses in Mechanics

1—ANALYTICAL MECHANICS—As a text for this subject, Rankine's *Applied Mechanics* is used; attention being confined chiefly, however, to Part I, Principles of Statics (including hydrostatics); Part III, Principles of Kinematics; and Part V, Principles of Dynamics (including hydrodynamics). This text is supplemented by lectures on special topics, by written solutions and discussions of typical problems, and by demonstrations with the aid of apparatus. Particular attention is given to the doctrine of units and dimensions of units, and to problems affording actual applications of principles. 3 hours, second half second year and first half third year. Professor WOODWARD

4—THERMODYNAMICS, with special reference to its bearing on the theory of caloric engines. 3 hours, second half fourth year. Professor PUPIN

20—THERMODYNAMICS, with special reference to its bearing on the theory of heat engines—2 hours, first half fourth year. Dr. WILLS

21—ELEMENTARY MECHANICS—Loney's *Elements of Statics and Dynamics.* 3 hours, first half second year. Dr. WILLS

Courses in Metallurgy

A—UNDERGRADUATE COURSES

1—GENERAL METALLURGY—Calorimetry, refractory materials, fuels (natural and artificial), pyrometry. 2 hours lectures a week during February, third year. Professor STOUGHTON

Pre-requisite: Chemistry 1 and Physics 1, or equivalent, and Metallurgy 4
Required of third-year students in the Schools of Mines and Chemistry

101—THE METALLURGY OF FUELS—Extension of Metallurgy 1. 1 hour lecture and conference per week during February and March, third year. Professor STOUGHTON

Required of third-year students in Metallurgy

2—THE METALLURGY OF STEEL AND IRON—The properties of steel, cast iron, and wrought iron, as influenced by composition and by thermal and mechanical treatment, together with a brief account of the chief processes by which they are made. Text-book: Howe's *Iron, Steel, and other Alloys.* 3 hours lectures a week during January, first half fourth year. Professor STOUGHTON

Pre-requisite: Metallurgy 1
Required of fourth-year students in Mining Engineering and Chemistry

3—The Metallurgy of Iron and Steel—The microscopic constitution of iron and steel. The properties of iron and steel as influenced by chemical composition, by mechanical treatment, and (as in case of malleable castings, chilled castings, and steel) by thermal treatment, such as hardening, tempering, and the various classes of annealing. Iron and steel founding, and the prevention and cure of the defects of iron and steel castings. Iron- and steel-making processes, the blast furnace, puddling, the Bessemer, open hearth, crucible, and minor processes. Rolling and forging metals. Text-books: Howe's *Iron, Steel, and other Alloys;* H. H. Campbell's *Iron and Steel.* 2 hours a week, second half second year. Professor Stoughton

Pre-requisite: Chemistry 1 and Physics 1, or equivalent
Required of second-year students in the course in Metallurgy, Electrical Engineering, Civil Engineering, and Mechanical Engineering; and of fourth-year students in Analytical Chemistry.

103—The Metallurgy of Iron and Steel—Extension of Metallurgy 3. 2 hours lecture or conference per week, second half, second year. Professor Stoughton

Required of second-year students in Metallurgy

4—Metallurgy of Copper—The properties of copper and of its alloys; the reverberatory and cupola-smelting processes for oxide and for sulphide ores; the converter or Bessemerizing process; minor smelting process; wet and electrolytic processes. Text-book: Peter's *Modern Copper Smelting.* 2 hours lectures a week, first half of third year. Dr. Bolles

Pre-requisite: Chemistry 1 and Physics 1, or equivalent
Required of third-year students in the Schools of Mines and Chemistry

104—The Metallurgy of Copper—Extension of Metallurgy 4. 1 hour lecture or conference per week, first half, third year. Dr. Bolles

Required of third-year students in Metallurgy

5a—Metallurgy of Lead—The properties of lead; properties of its alloys and their constitution; the reverberatory, the ore-hearth and the blast-furnace processes; desilverization of base bullion. Text-book: Hofman's *Metallurgy of Lead and Desilverization of Base Bullion.* 2 hours lectures a week, April and May, second half, third year. Dr. Campbell

Pre-requisite: Metallurgy 4
Required of third-year students in the schools of Mines and Chemistry

105a—The Metallurgy of Lead—Extension of Metallurgy 5a. 1 hour lecture or conference per week during April and May, third year. Dr. Campbell

Required of students in Metallurgy

5b—Metallurgy of Silver, Gold, Zinc and the Minor Metals—Properties; alloys; ores; methods of extraction, separation and refining

Text-books: Collins' *Metallurgy of Silver,* Rose's *Metallurgy of Gold,* Ingalls' *Metallurgy of Zinc.* 3 hours lectures a week, October, November and December, fourth year. Drs. CAMPBELL and BOLLES

Pre-requisite: Metallurgy 1, 4, and 5a (and Metallurgy 20 for students in the School of Mines)

Required of fourth-year students in the Schools of Mines and Chemistry

105b—THE METALLURGY OF SILVER, GOLD, ZINC, ETC.—Extension of Metallurgy 5b. 1 hour lecture or conference a week during October, November and December, fourth year. Drs. CAMPBELL and BOLLES

Required of students in Metallurgy

6—LABORATORY WORK—Pyrometry; the calorific power of fuels; the microscopic study of metals and alloys; the thermal and mechanical treatment of steel and cast iron; the roasting and smelting of copper ores; refining black copper; desilverizing base bullion; cupelling, roasting, lixiviating, cyanide and chlorination processes; the fusibility and other properties of slags and of refractory materials. (See p. 10, Metallurgical Laboratory Notes.) Text-book: Howe's *Metallurgical Laboratory Notes.* 4 afternoons a week, second half third year. All officers.

Pre-requisite: Metallurgy 3, 4; and pre-requisite or parallel: Metallurgy 1 and 5a.

Required of third-year students in the course of Metallurgy

6a—LABORATORY WORK—Pyrometry; microscopic metallography; the thermal treatment of steel; roasting processes; and desilverizing base bullion. Text-book: Howe's *Metallurgical Laboratory Notes.* 10 afternoons in the fourth year. All officers.

Pre-requisite: Metallurgy 1, 4, and 5a; and pre-requisite or parallel: Metallurgy 2 and 5b.

Required of fourth-year students in the course of Mining Engineering

109—THE CONSTITUTION AND PROPERTIES OF ALLOYS. Text-book: Howe's *Iron, Steel and Other Alloys.* 3 hours lecture or conference a week during January, fourth year. Dr. CAMPBELL

Required of students in Metallurgy

30—THESIS

Pre-requisites: Metallurgy 1, 4, 5a, and 6a.

B—GRADUATE COURSES

Special courses, consisting of personal instruction and original experimental investigation, will be arranged for advanced students according to their individual needs and ability. Some of these investigations will be made at metallurgical works into processes in actual use there, others in the metallurgical and analytical laboratories of the Department.

The amount of time required for these courses varies, being governed by the rule that a course or courses should occupy 18 hours a week (preparation included) if taken as a major subject, and 9 hours a week if taken as a minor subject, for a degree of A.M., or half minor for a Ph.D. degree.

7—Advanced Course in Calorimetry—Determination of the calorific power of fuel

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

8—Advanced Course in Pyrometry—Determination of the temperatures of metallurgical and other high-temperature operations, *e.g.*, of the Bessemer converter for steel and for copper, the open-hearth steel furnace, the iron-blast furnace, the copper and lead-smelting cupola furnace, steam-boiler fires, etc.

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

9—Microscopic Study of Iron, Steel, and other Metals—Preparation and microscopic examination of specimens.

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

10—The Heat-treatment of Steel, and other Metals, with determination of the resultant effects on the physical properties and microstructures

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

11—The Formation-points, Melting-points, and Specific Heat of Slags, and their density and viscosity when molten

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

12—The Influence of Strain upon Properties of Metals

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

13—The Chemistry of Roasting Processes, including the expulsion of arsenic and antimony

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

14—The Chemistry of the Iron Blast Furnace

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

15—The Chemistry of Basic Dephosphorizing Processes

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

16—Search for New and Useful Alloys

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

17—Fire-brick and other Refractory Materials, their resistance to heat and to corrosion

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

18—Electrolytic Refining and Depositing Processes

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

19—Wet Processes for Extracting Gold, Silver, and Copper

Pre-requisite: Metallurgy **1**, **3**, **4**, **5a**, and **5b**, or equivalent

The following courses taken together will count as a minor for the degree of A.M., or as a partial minor for the degree of Ph.D. Either:

(a) Numbers **1**, **3**, **4**, **5** (**a** and **b**), and **6a**;
(b) " **1**, **3**, and **6**;
(c) " **4** and **6** with either **1**, **2**, **3**, **5a** or **5b**

C—Summer Courses

20 and 21—Summer Courses in Metallurgy—One week is spent at metallurgical works in studying the operations there carried out. The students are given individual and class instruction, and are required to make complete descriptions of the various processes, including sketches of furnaces and apparatus

Hereafter the summer courses will be in the vacation between the second and third, or third and fourth years, and will be in two divisions. The first, Course 20, required of students in Mining Engineering, will visit copper, lead, gold, and silver works; the second, Course 21, required of students in Mechanical Engineering, will visit iron and steel works. The two courses will be given at different times, and students in Metallurgy will be required to attend both. Professor Stoughton, Dr. Campbell, and Dr. Bolles

Metallurgy 21, being a second year subject, students in metallurgy will be required to spend three weeks each in Courses 20 and 21

Pre-requisite for Course 20: Metallurgy 1, 4, and 5a
Pre-requisite for Course 21: Metallurgy 2 or 3

Courses in Mineralogy

6—Optical Mineralogy—Principles, apparatus, and distinguishing characters of minerals in thin sections. 2 afternoons laboratory work for two months of second half of third year. Professor Luquer

12—Descriptive and Determinative Mineralogy—First half-year: The elements of crystallography. The use of the blowpipe in determination of silicates and borates. The minerals of carbon and sulphur, the borates and the rock-forming silicates

Second half-year: The blowpipe analysis of ores and other substances, and the study of the important economic minerals. 3 hours lectures and conferences, 2 afternoons, laboratory. Professor Moses, Professor Luquer and assistants

Pre-requisites: Chemistry 6 and Physics 31
Minor for the degree of A.M.

Courses in Mining

1—Excavation and Tunneling—3 hours, first half third year. Professor Peele

Excavation of earth: tools and methods employed, support of excavations, special methods for quicksand and other water-bearing material; steam shovels and other mechanical excavators; handling and transportation of excavated material; comparative costs. Explosives: black powder, nitro-glycerine and its compounds, and other high explosives; their nature, manufacture, and use. Excavation of rock: methods of drilling and blasting, mammoth blasts, submarine blasting. Quarrying: plant and methods for quarrying different rocks. Railroad tunnels:

methods of driving and timbering; handling and transportation of excavated material; drainage and ventilation; permanent lining of tunnels; submarine tunnels. Mine tunnels: examples from practice: sizes, details of driving, timbering, speeds of advance and costs

Required of students in the course of Mining Engineering

Pre-requisites: Entrance requirements in Mathematics, Chemistry, and Physics

2—Boring and Shaft Sinking—2 hours, second half third year. Professor Peele

Boring: methods and appliances for small depths and for deep boring; rod boring and cable tool or oil-well method; boring with diamond drill, for prospecting and other purposes; survey of bore-holes. Shaft sinking: methods and tools employed in soft material and in rock; sinking linings or drop-shafts, and other special methods of sinking in water-bearing formations and quicksand; drainage of shafts; handling and hoisting of excavated material. Shaft timbering, walling, tubbing, and other modes of lining

Required of students in the course of Mining Engineering

Pre-requisite: Mining 1

3—Exploration, Development, and Methods of Working—3 hours, second half third year. Professor Munroe

Mineral deposits, characteristic of beds, masses, veins, and other deposits, and the irregularities and disturbances to which they are subject, as affecting the work of exploration and mining. Examination and survey of mineral properties; relation of topography to geological structure; construction of maps and sections; and tracing of probable outcrops as a guide to exploration. Prospecting by ditches, pits, and deep boring. Development; choice of methods; location of openings. Working of deposits and support of excavations; theoretical considerations, methods of breaking ground in coal and metal mining, and support of mine excavations by pillars of mineral, by timbering, by masonry, and by rock filling; methods of working applicable to deposits of different thickness, inclination, and character. Coal mining; vein mining; working of thick deposits and soft-ore bodies. Salt mining. Surface workings. Hydraulic mining

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisites: Mineralogy 12, Geology 2. Pre-requisites or parallels: Geology 3, Mining 1 and 2

Counts, together with Mining 4 and 5, or with Mining 6, 9, and 10, as a minor for the degree of A.M.

4—Ore Dressing, Milling, and the Mechanical Preparation of Coal—2 hours, fourth year. Professor Munroe

The general principles and theory of dressing; preliminary operations; hand dressing; cleansing; crushing; jigging with and without preliminary sizing; slime concentration; milling of gold and silver

ores; and descriptions of typical dressing works and coal-washing plants in this country and abroad

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisites: Mineralogy **1** or **12**, Physics **1**. Pre-requisite or parallel: Mechanics **1** or **21**

Counts, together with Mining **3** and **5**, or with Mining **5**, **7a**, and **8**, as a minor for the degree of A.M.

5—Ore-dressing Laboratory—Afternoon work for three weeks, second half fourth year. Professor Munroe and Mr. Kurtz

Mechanical testing of ores by laboratory methods; working tests with simple apparatus; adjustment and operation of concentrating machines

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisite or parallel: Mining **4**

Counts, together with Mining **3** and **4**, or with Mining **4**, **7a**, and **8**, as a minor for the degree of A.M.

6—Mine Engineering—2 hours second half fourth year. Professor Munroe

Surface handling and transportation; arrangements for loading and unloading cars and vessels, and for storing of minerals. Mineral railroads. Common roads. Drainage: sources of mine waters; methods for the control and raising of water; dams; drainage levels. Water supply. Ventilation; air of mines; mine gases; methods of ventilation; control and measurement of air currents. Accidents to men in shafts, levels and working places; fire-damp and dust explosions; mine fires; inundations; rescue and relief of men

Required of students in the course of Mining Engineering

Pre-requisites or parallels: Mining **3** and **7**, Civil Engineering **12** and **17**

Counts, together with Mining **3**, **9**, and **10**, as a minor for the degree of A.M.

7—Mine Plant—3 hours, fourth year. Professor Peele

Descriptions and critical discussion of the machinery and appliances employed in the equipment of mines; design, erection and care of plant. Hoisting: engines, drums, wire rope, skips and cages, head-frames; calculation of power required and methods of equalizing the load on the engine; over-winding, shaft-sinking plant. Drainage: buckets, tanks and hand-pumps; Cornish and direct-acting underground pumps; operation of pumps by electricity, compressed air, and hydraulic power. Ventilation: natural ventilation, underground furnaces, positive blowers, and centrifugal fans; efficiencies of fans. Air compressors: straight-line and duplex; simple and compound (stage) compression; methods of dealing with heat of compression; conveyance of compressed air in pipes; reheating; operation of machinery by compressed air; efficiencies. Machine drills: their construction and operation. Coal-mining machines or coal-cutters. Handling mineral in working places. Mine cars: arrangement and construction of tracks. Underground haulage;

hand tramming; mule haulage; gravity roads; steam, compressed-air, and electric locomotives; rope haulage; efficiencies; comparison of systems of haulage

Required of students in the course of Mining Engineering

Pre-requisites: Mining **1**, **2**, and 3, and Mechanical Engineering **111**. Parallels: Mechanical Engineering **12** and **13**

Counts, together with Mining **7a** and 8, as a minor for the degree of A.M.

7a—MINE CONSTRUCTIONS—1 hour, second half third year. Professor PEELE

Building-stones; bricks; limes; cements and concretes. Foundations in various soils; retaining walls; masonry and timber construction, with special reference to mine work; mine buildings; trestles; ore-bins

Required of students in the courses of Mining and Metallurgical Engineering

Counts, together with Mining **7** and **8**, or with Mining **4**, **5**, and **8**, as a minor for the degree of A.M.

8—DESIGN OF MINE PLANT—5 afternoons first half fourth year. Professor PEELE and Mr. KURTZ

The students are assigned problems in the design and construction of mine plant, in connection with the development of a mine. This work supplements the lectures on the design of mining machinery, involving reading and study, and the preparation of working drawings, covering certain portions of the plant, together with bills of material, specifications, and estimates. As these drawings are intended to accompany and illustrate in part the graduating theses or projects, the designs are made in accordance with the subjects and conditions assigned to each student. The work is done under constant supervision and advice in the draughting-room

Required of students in the course of Mining Engineering

Pre-requisites: Mechanical Engineering **1** and **2**, Civil Engineering **5**. Parallel: Mining **7**

Counts, together with Mining **7** and **7a**, or with Mining **4**, **5**, and **7a**, as a minor for the degree of A.M.

9—MINE SURVEYING AND MINE EXAMINATION—1 hour for three months, first half fourth year. Professor MUNROE

This course supplements the practical work in underground surveying in connection with the summer school in mining. It includes the general principles of underground surveying, the construction of mine maps and sections, and of models of mine workings, the measurement of contracts, the location of lines for new work; examination, sampling, and valuation of mines

Required of students in the course of Mining Engineering

Pre-requisites: Civil Engineering **1**, **15**, and **16**

Counts, together with Mining **3**, **6**, and **10**, as a minor for the degree of A.M.

10—ADMINISTRATION AND MINE ACCOUNTS—1 hour, fourth year. Professor MUNROE and Mr. KURTZ

Administration, organization, and business management, mine accounts, and cost sheets

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisite or parallel: Mining 6

Counts, together with Mining 3, 6, and 9, as a minor for the degree of A.M.

25—Graduating Thesis or Project—Professor Peele

Required of students in the course of Mining Engineering.

Pre-requisites or parallel: All the courses in Mining

26—Mill Constructions—Installation and operation of mechanical power transmission and auxiliary machinery in works for the mechanical treatment of minerals. Dealing with shafting, bearings, pulleys, belting, rope drives, gearing, etc. 1 hour a week, second half third year. Mr. Kurtz

Summer Courses

11—The Summer Courses in Practical Mining are held in June and July, at some mine or mines selected for the purpose, in the vacation between the third and fourth years, and last six weeks, including one week field geology (for details see pages 16-17). Professor Peele, Mr. Kurtz and Assistants

Pre-requisites or parallels: Mining 3 and 4

Graduate Courses

Special courses, consisting of personal instruction, reading, and experimental investigation, will be arranged for advanced students according to their individual needs and ability. These investigations will be made at mines and dressing works either in connection with the Summer School or elsewhere as assigned, with additional work, as required, in the library and in the laboratories of the department. These courses vary in difficulty and in the amount of time necessary, according as the student is a candidate for the degree of A.M. or Ph.D., and according as he pursues mining as a major or a minor subject. The time required is governed by the rule that a course or courses should occupy about 18 hours (outside reading and study included) per week if taken as a major subject, and about 9 hours per week if taken as a minor subject. The following are suggested:

12—Methods of Mining—Critical study of methods used in some mining region, or for a certain class of deposits; output per man, amount of timber and explosive required, and other details affecting cost. Study of conditions as determining choice of method. Determination of loss of mineral in mining. Accidents to men

Pre-requisites: all the courses in Mining

Major or minor for the degree of A.M. or Ph.D.

13—MINING PLANT—Critical study of rock drilling, or coal cutting, or hoisting, or haulage, or ventilating plant at some mine or mines. Determination of efficiency and conditions affecting same

Pre-requisites: all the courses in Mining
Major or minor for the degree of A.M. or Ph.D.

14—DEEP MINING—Study of problems of deep mining, vertical versus inclined shafts, hoisting and pumping from great depths, temperature and ventilation, efficiency of labor, rock pressure as affecting methods of mining and timbering

Pre-requisites: all the courses in Mining
Major or minor for the degree of A.M. or Ph.D.

15—ORE DRESSING—Critical study of some detail of the ordinary dressing methods, crushing, or screening, or classification, or jigging, or slime treatment, or dry concentration, or magnetic separation, or milling of gold or silver ores, or mechanical preparation of coal. Determination of efficiency, and of conditions essential to success

Pre-requisites: all the courses in Mining
Major or minor for the degree of A.M. or Ph.D.

16—EXAMINATION OF A COAL-WASHING PLANT, OR OF AN ORE-DRESSING PLANT—4 to 6 weeks work in the mill and in the laboratory, with conferences

Pre-requisites: all the courses in Mining
Minor for the degree of A.M.

17—EXAMINATION OF A MINERAL PROPERTY, OR A MINE—4 to 6 weeks devoted to field and underground work in the summer school of practical mining, with conferences at convenience of professor

Pre-requisites: all the courses in Mining
Minor for the degree of A.M.

18—ECONOMIC STUDIES IN MINING—Study of existing conditions affecting the production and cost of some mineral or metal, as, for example, anthracite coal, copper, or gold

Pre-requisites: all the courses in Mining
Major or minor for the degree of A.M.

19—MINING AND ORE DRESSING—Mining 3, 4, and 5. 4 hours, with laboratory work and reading as required

Pre-requisites: Mining 1 and 2. Count together as a minor for the degree of A.M.

20—MINING ENGINEERING—Mining 3, 6, and 10. 3 hours lectures and reading as required

Pre-requisites: Civil Engineering 5 and Mining 1 and 2. Count together as a minor for the degree of A.M.

21—DESIGN OF MINE PLANT—Mining 7, 7a, and 8. 3 hours and 5 afternoons draughting-room work

Pre-requisites: Civil Engineering 5 and Mining 1, 2, and 3. Count together as a minor for the degree of A.M.

22—DESIGN OF ORE-DRESSING WORKS—Mining 4, 5, 7a, and 8, with 1 hour conference additional first half-year. 3 hours, and 5 afternoons laboratory and draughting-room work

Pre-requisite: Civil Engineering 5. Count together as a minor for the degree of A.M.

23—MINING—1, 2, 3, 4, 5, 6, 7, 7a, 8, 9, 10, 11, 24, 25, being all the undergraduate courses in the department of Mining

Count together as a major and one minor for the degree of A.M. Open only to students who have a first degree, and who are candidates for the degrees of E.M. and A.M. See regulations for higher degrees

Courses in Physics

1—GENERAL PHYSICS—Mechanics, Properties of Matter, and Electricity (first half-year). Sound, Heat, and Light (second half-year). 3 hours lectures and recitations, first year. Drs. TUFTS, DAY, DAVIS, and Mr. PEGRAM

3—LABORATORY WORK IN GENERAL PHYSICS—4 hours, first half second year. Professor PARKER

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SCHOOLS OF MINES, ENGINEERING AND CHEMISTRY

MINING

METALLURGY

CIVIL ENGINEERING

ELECTRICAL ENGINEERING

MECHANICAL ENGINEERING

CHEMICAL ENGINEERING

CHEMISTRY

ANNOUNCEMENT

1907-1908

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These include:

1. The Report of the President and the Treasurer to the Trustees.
2. The Catalogue of the University, issued in December, price 25 cents.
3. The Announcement of the several Colleges, Schools and Divisions, issued in the Spring and relating to the work of the next year. These are made as accurate as possible, but the right is reserved to make changes in detail as circumstances require. The current number of any of these Announcements will be sent without charge upon application to the Secretary of the University.

B-June-6000.

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THE FACULTY OF APPLIED SCIENCE

Officers of the Faculty

NICHOLAS MURRAY BUTLER.............. *President of the University*
A.B., Columbia, 1882; A.M., 1883; Ph.D., 1884; LL.D., Syracuse, 1898; Tulane, 1901; Johns Hopkins, Princeton, Yale, and University of Pennsylvania, 1902; Chicago, 1903; Manchester and St. Andrew's, 1905; Litt.D., Oxford, 1905.

FREDERICK ARTHUR GOETZE........................*Dean of the Faculty*
M.Sc., Columbia, 1905.

J. HOWARD VAN AMRINGE..................*Professor of Mathematics*
A.B., Columbia, 1860; A.M., 1863; L.H.D., 1890; Ph.D., University of the State of New York, 1877; LL.D., Union, 1895.

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A.M., Ph.D., Göttingen, 1856; M.D., University of New York, 1873; LL.D., Union, 1873; Sc.D., Oxford, 1900.

HENRY S. MUNROE...........*Professor of Mining, and Delegate to the University Council*
E.M., Columbia, 1869; Ph.D., 1876; Sc.D., 1904.

ALFRED J. MOSES...........................*Professor of Mineralogy*
E.M., Columbia, 1882; Ph.D., 1890.

JAMES FURMAN KEMP..........................*Professor of Geology*
A.B., Amherst, 1881; Sc.D., 1906; E.M., Columbia, 1884.

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E.M., Columbia, 1883.

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A.B., Columbia, 1879; Ph.D., Würzburg, 1881; Phar.D., National College of Pharmacy, 1892.

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E.M., Columbia, 1882; Ph.D., 1895.

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A.B., Columbia, 1883; Sc.D., 1904; Ph.D., Berlin, 1889.

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C.E., Rensselaer Polytechnic, 1872.

THOMAS SCOTT FISKE......................*Professor of Mathematics*
A.B., Columbia, 1885; A.M., 1886; Ph.D., 1888.

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A.B., Columbia, 1885; Ph.D., 1895.

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B.S., Harvard, 1869; A.M., 1872; LL.D., 1905; B.S., Mass. Institute of Technology, 1871; LL.D., Lehigh, 1905; LL.D., Harvard, 1905.

CHARLES E. PELLEW..................*Adjunct Professor of Chemistry*
E.M., Columbia, 1884.

Earl B. Lovell.......................*Professor of Civil Engineering*
C.E., Cornell, 1891.

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B.S., Massachusetts Institute of Technology, 1885.

George Francis Sever.............*Professor of Electrical Engineering*
M.Sc., Columbia, 1905.

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C.E., Columbia, 1888; Ph.D., 1899.

Marston Taylor Bogert.............*Professor of Organic Chemistry*
A.B., Columbia, 1890; Ph.B., 1894.

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B.S., Rutgers, 1892; A.M. and Ph.D., Leipzig, 1895.

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S.B., Massachusetts Institute of Technology, 1896; S.M., Harvard, 1898; S.D., 1900.

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C.E., Columbia, 1879.

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E.M., Columbia, 1885.

Cassius Jackson Keyser ....*Adrain Professor of Mathematics*
B.S., Missouri, 1892; A.M., Columbia, 1896; Ph.D., 1901.

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Ph.B., Columbia, 1875; Ph.D., 1877.

Joseph C. Pfister....................*Adjunct Professor of Mechanics*
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B.S., Maryland Agricultural College, 1893; A.M., Columbia, 1896; Ph.D., 1897.

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B.E.E., Tufts, 1894; Ph.D., Clark, 1897.

Samuel A. Tucker...........*Adjunct Professor of Electro-Chemistry*
Ph.B., Columbia, 1895.

Adolph Black................*Adjunct Professor of Civil Engineering*
C.E., Columbia, 1894.

CHARLES EDWARD LUCKE. *Adjunct Professor of Mechanical Engineering*

B.S., College of the City of New York, 1895; M.S., New York University, 1899; Ph.D., Columbia, 1902.

WALTER RAUTENSTRAUCH............ *Adjunct Professor of Mechanical Engineering*

B.S., University of Missouri, 1902; M.S., University of Maine, 1903.

WILLIAM CAMPBELL.............. *Adjunct Professor of Metallography*

B.Sc., Durham University, 1898; D.Sc., 1905; M.Sc., Royal School of Mines, 1903; Ph.D., Columbia, 1903; A.M., 1905.

Instructors

EDWARD LAWRENCE KURTZ, E.M.................. *Instructor in Mining*
CHARLES C. TROWBRIDGE, M.S.................... *Instructor in Physics*
GEORGE H. LING, PH.D.................... *Instructor in Mathematics*
GEORGE BRAXTON PEGRAM, PH.D................ *Instructor in Physics*
WALTER R. CRANE, PH.D....................... *Instructor in Mining*
MORTON ARENDT, E.E............. *Instructor in Electrical Engineering*
VICTOR J. CHAMBERS, PH.D.......... *Instructor in Organic Chemistry*
EVERETT J. HALL............................ *Instructor in Assaying*
BERGEN DAVIS, PH.D........................... *Instructor in Physics*
CHARLES PETER BERKEY, PH.D.................. *Instructor in Geology*
FLOYD J. METZGER, PH.D.......... *Instructor in Analytical Chemistry*
HARRY L. PARR, A.B., MECH.E... *Instructor in Mechanical Engineering*

Tutors

SAMUEL OSGOOD MILLER, C.E...................... *Tutor in Drawing*
CAVALIER HARGRAVE JOÜET, PH.D...... *Tutor in Analytical Chemistry*
THOMAS H. HARRINGTON, C.E...................... *Tutor in Drawing*
ARTHUR COLON NEISH, PH.D..................... *Tutor in Chemistry*
CHARLES H. ELLARD, A.M.............. *Tutor in Analytical Chemistry*
HAL T. BEANS, PH.D................. *Tutor in Analytical Chemistry*
WILLIAM S. DAY, PH.D........................... *Tutor in Physics*
MAURICE A. LAMME, B.S........................ *Tutor in Mineralogy*
ARTHUR RAY MAXSON, A.M.................... *Tutor in Mathematics*
EDWARD F. KERN, B.S., PH.D.................. *Tutor in Metallurgy*
LEWIS P. SICELOFF, A.B...................... *Tutor in Mathematics*
CHARLES E. MORRISON, C.E., A.M........ *Tutor in Civil Engineering*
OTTO KRESS, B.S.............................. *Tutor in Chemistry*
EDWARD J. KUNZE, B.S., M.E........ *Tutor in Mechanical Engineering*
EDGAR S. DOWNS, PH.D............. *Tutor in Electrical Engineering*

Lecturers

MYRON P. FALK, PH.D................ *Lecturer in Civil Engineering*

Assistants

William C. Uhlig, Ph.D.......... *Assistant in Analytical Chemistry*
Micco M. A. Fontrier, A.B.................. *Assistant in Mechanics*
Morris F. Weinrich, Mech.E.................. *Assistant in Drawing*
Julian Blanchard, A.B........................ *Assistant in Physics*
Hermon W. Farwell, A.M...................... *Assistant in Physics*
Leighton B. Morse, Ph.B....................... *Assistant in Physics*
Cornelis Offerhaus, Ph.D.................. *Assistant in Metallurgy*
J. Edwin Sinclair, B.S............. *Assistant in Analytical Chemistry*
Chauncey C. Chapin, B.S., Ph.D.............. *Assistant in Physics*
Kaufman G. Falk, B.S., Ph.D...... *Assistant in Physical Chemistry*
Charles Arthur Stewart, A.B.............. *Assistant in Mineralogy*
Harry Wilfred Reddick, A.M.............. *Assistant in Mathematics*
Charles E. Taylor, B.S., A.M...... *Assistant in Analytical Chemistry*
Edwin Kirk, A.B......................... *Assistant in Palæontology*
Edward D. Thurston, Jr., A.B., Mech.E...... *Assistant in Mechanical Engineering*
Francis S. Foote, Jr., E.M.............. *Assistant in Civil Engineering*
Victor R. Greiff, E.E............ *Assistant in Electrical Engineering*

Non-Resident Lecturers for 1906-07

O. B. Perry, E.M., Consulting Engineer.

R. V. Norris, E.M., Consulting Engineer, Pennsylvania Coal Companies.

H. P. Gillette, E.M., Associate Editor, Engineering News.

Charles Piez, E.M., General Manager and Chief Engineer, Link Belt Engineering Co.

Geo. C. Stone, E.M., Chief Engineer, New Jersey Zinc Co.

B. B. Lawrence, E.M., Consulting Engineer.

J. A. Church, E.M., Ph.D., Consulting Engineer.

J. Parke Channing, E.M., President Tennessee Copper Co.

James Douglas, LL.D., President of the Copper Queen Mining Company.

F. Louis Grammer, Consulting Metallurgist.

Capt. Robert W. Hunt, Consulting Engineer.

Rossiter W. Raymond, Ph.D., LL.D., Secretary, The American Institute of Mining Engineers.

F. N. Waterman, E.E., Electrical Engineer, N. Y. Central.

W. S. Murray, E.E., Electrical Engineer, N. Y., N. H. & H. R. R.

H. G. Stott, M.E., Engineer of Motive Power, Interborough R. T. Co.

W. G. Clark, Managing Engineer, Kilbourne & Clark Co.

W. B. Snow, M.E., Engineer, Sturtevant Co.

P. R. Moses, E.E., Consulting Engineer.

T. Commerford Martin, Editor, Electrical World.

F. W. Willcox, Edison Lamp Works.

James Dixon, E.E., Gray National Telautograph Co.

C. W. Obert, M.E., Assoc. Editor, Street Railway Journal.

Richard G. G. Moldenke, E.M., Ph.D., Consulting Metallurgist.

W. S. Barstow, E.E., Consulting Electrical and Mechanical Engineer.

John Hays Hammond, Ph.B., A.M., Mining Engineer.

Admiral Melville, E.M., LL.D., Engineer in Chief (retired), U. S. N.

Standing Committees of the Faculty

On Administration. The Dean (Chairman), Professors Van Amringe, Peele, Sever and Lovell.

On Admissions. Professors Maclay (Chairman), Mayer, Luquer, Stoughton and Tucker.

University Officers of Administration

Frederick P. Keppel, A.B. .... *Secretary of the University*

Rudolf Tombo, Jr., Ph.D. .... *Registrar of the University*

George F. Fisher .... *Bursar*

Henry L. Norris, M.E. ...... *Superintendent of Buildings and Grounds*

Librarian of the University

James H. Canfield, LL.D., Litt.D. (Oxon.)

Acting Chaplain of the University

G. Ashton Oldham, A.B.

Medical Director of the Gymnasium

George L. Meylan, M.D.

Secretary of Earl Hall

Harry T. Baker, A.M.

University Medical Visitor

D. Stuart Dodge Jessup, M.D.

COLUMBIA UNIVERSITY

Columbia University was founded in 1754 as King's College. In 1784, after the Revolutionary War, King's College became, by act of the Legislature of the State of New York, Columbia College. The institution whose name was thus changed has become Columbia University.

The first step for the foundation of a School of Applied Science was taken in 1864, when the Trustees approved the creation of a School of Mines, in which courses were later established in civil engineering, chemistry, and metallurgy. The growth of these courses, and the addition of the course in architecture during the decade of 1880 to 1890, made it seem desirable to adopt some more comprehensive name than the historic title "School of Mines," so that in 1896 the Schools of Engineering and Chemistry were set off from the School of Mines, which remained, however, as one of the Schools of Applied Science, under its appropriate Faculty. Each School, therefore, conducts separate courses of study leading to the appropriate degree.

SCHOOLS UNDER THE FACULTY OF APPLIED SCIENCE

The Faculty of Applied Science has charge of the following schools:

1. The School of Mines, with four-year courses leading to the degrees of Engineer of Mines and of Metallurgical Engineer.

2. The Schools of Engineering, with four-year courses in Civil Engineering, Sanitary Engineering, Electrical Engineering, and Mechanical Engineering, the first two leading to the degree of Civil Engineer, and the others to the degree of Electrical Engineer and Mechanical Engineer respectively.

3. The School of Chemistry, with four-year courses, leading to the degrees of Chemist and Chemical Engineer.

The courses are intended to meet the requirements of the several professions indicated. Many of the courses permit a certain amount of specialization, particularly in the fourth year. The courses in the School of Mines are so arranged that the student can emphasize the engineering, the metallurgical, or the geological side of his profession.

A course in Sanitary Engineering (leading to the degree of Civil Engineer) is provided for those who wish to prepare themselves for this important branch of civil engineering.

Candidates for a professional degree who have some special end in view are sometimes permitted to vary the regular course by substi-

tuting, for the courses ordinarily prescribed, courses for other degrees offered under the Faculty of Applied Science. No provision is made for partial courses under this Faculty. Students holding an academic degree who become candidates for the degree of Master of Arts or Doctor of Philosophy may offer work in one or more of these branches of technology either as a major or a minor subject under the Faculty of Pure Science and will be given opportunity for special study and investigation (see page 100). Non-matriculated students, properly qualified by age, special training and experience and by ability, may sometimes pursue advanced studies or original research.

ADMISSION

Except for reasons of weight, candidates for admission to the first-year class must be at least eighteen years of age at the time of matriculation, and correspondingly older for admission to advanced standing. Each candidate must before admission present a certificate of good moral character from his last teacher or from some citizen of good standing. Students from other colleges or universities must bring certificates of honorable dismission. Students are admitted subject to the disciplinary powers of the University authorities.

All requests for information regarding admission should be addressed to the Secretary of the University.

Collegiate Preparation Recommended

The liberal training offered by a preliminary Collegiate Course is quite as important to engineers, metallurgists and chemists as to lawyers, physicians or clergymen, and is strongly recommended by the Faculty of Applied Science. This, however, does not and should not involve a residence of eight years in college and technical school before a candidate receives the professional degree.

A graduate of any good college who has selected his course with reference to future work in applied science is able to complete the requirements for a degree in the Schools of Mines, Engineering and Chemistry in less than four years after receiving the Bachelor's degree. The opportunities for close articulation between Columbia College and these Schools are, however, particularly good. Under the provisions of the new program it is possible for a well-prepared student to complete the requirements for both the collegiate and professional degrees in a period of six, five and a half, or five years. A specimen curriculum of this combined course will be found on page 99.

Minimum Entrance Requirements

To the First Year Class

Every candidate must offer at the entrance examinations (see below) subjects amounting to fifteen "points." A point represents a course of five periods a week for one year in the secondary school.

Adopted April 26, 1907, and superseding the statement on page 12 of the Bulletin of Entrance Examinations of 1907, page 14 of the Announcement of the Division of Engineering, and page 237 of the University Catalogue for 1906-7.

	Counting in Points	
Total requirement	15	points

The candidate must offer:

Chemistry	1	"
Drawing	1	"
Elementary French or Elementary German	2	"
English	3	"
Mathematics	4	"
Physics	1	"

and three points from the following, subject to the restriction that to offer an advanced subject will involve offering either at the same time or earlier the corresponding elementary subject:

Elementary German or Elementary French — *see above*	2	points
Elementary Spanish	2	"
Elementary Latin	2	"
Intermediate French	1	"
Intermediate German	1	"
Ancient History	1	"
Modern and Mediæval History	1	"
American History	1	"
English History	1	"
Botany	1	"
Physiography	1	"
Zoölogy	1	"
Shopwork	1	"
Advanced Physics	1	"

All candidates for degrees of Engineer of Mines, Metallurgical and Chemical Engineer or Chemist, are recommended to offer Elementary and Intermediate German.

Except for reasons of weight no student will be admitted with a condition in Mathematics, Chemistry, or Physics. It is suggested that candidates deficient in these subjects in June arrange to take courses in them in the Summer Session of Columbia University, the announcement of which will be sent upon application to the Secretary of the University.

Entrance Examinations

Examinations for admission will be held in 1907, beginning June 17 and September 16 respectively, and in January, 1908, beginning on the 20th. The June examinations are those of the College Entrance Examination Board. These are held at Columbia University and at about 140 other places, including, in 1907, Portland, Me.; Boston and Springfield, Mass.; Hartford and New Haven, Conn.; Albany and Buffalo, N. Y.; Newark, N. J.; Allegheny and Philadelphia, Pa.; Baltimore, Md.; Washington, D. C.; Asheville, N. C.; Louisville, Ky.; Memphis, Tenn.; New Orleans, La.; Cincinnati and Cleveland, Ohio; Indianapolis, Ind.; Chicago, Ill.; Detroit, Mich.; Milwaukee, Wis.; Minneapolis, Minn.; Kansas City and St. Louis, Mo.; Denver, Colo.; Salt Lake City, Utah; Portland, Oregon; Los Angeles, Calif.; and in Europe, London, Paris, Geneva. The September and January examinations, conducted by the University Committee on Entrance Examinations, are held only at the University.

A candidate may present himself at any of the scheduled series of examinations subject to the following restrictions:

Division of Examinations

1. He may not present himself at more than four series of examinations except by special consent of the Committee on Admissions.
2. At the first and the second series credit will be given for only such subjects or lettered (or numbered) parts of a subject as are approved by his principal instructor.
3. The results of an examination shall stand to his credit for twenty-eight months, but no longer.

A copy of the time-scheme of the examinations, together with information as to the proper method of filing application blanks for these examinations, the payment of fees, and the division of examinations, and also detailed definitions of the requirements in each subject which may be counted for admission, is given in the Announcement of the Entrance Examinations for 1907, which may be had upon application to the Secretary of the University.

Report of Entrance Examinations

Each candidate taking examinations with the College Entrance Examination Board in June should send the report thereon to the Registrar of Columbia University immediately upon its receipt. He will then be advised as soon as possible whether he has been admitted with or without conditions, or in what subjects he must present himself for reëxamination.

In September candidates who wish to enter the University at once may obtain the results of their examination by calling at the Registrar's office on, or after, Tuesday, September 24, 1907. Others will be advised later by mail.

Certificates of Acceptance

The Committee on Admissions accepts in lieu of its entrance examinations no credentials of any sort except the Regents' Academic Diploma[1] and the certificates of approved colleges, and these only for the subjects which they specifically cover. The certificates of the preparatory or high school departments of universities and colleges are not accepted. Candidates must take the regular entrance examinations in the subjects in which their certificates are not deemed adequate. All certificates so offered must be received at least one week before the first day of the entrance examinations (in 1907 before September 9), and the names of those whose certificates are accepted in whole or in part will be posted at least one day before the examinations begin.

To Advanced Standing

Candidates for admission from other universities or colleges, and those desiring to be admitted to advanced standing on examination, must make application in writing to the Chairman of the Committee on Admissions of the Faculty of Applied Science in time to reach him before September 9, 1907.[2]

The application must be accompanied by:

1. A catalogue of the institution for work in which credit is desired. The courses which the candidate has completed must be distinctly marked in this catalogue.

2. Properly certified official statements of his standing in the subjects which he offers.

3. Letters or other evidence vouching for his character and honorable dismission from the institution from which he comes.

Every candidate for a degree seeking admission to advanced standing must show that he has attained proficiency in the equivalents of:

1. The requirements of admission to the first-year class.

2. All the prescribed studies already pursued by the class to which he seeks admission.

A candidate may be admitted notwithstanding deficiences in some of these studies, but no candidate will be recommended for a professional degree until he shall have completed all the studies required for that degree.

No applicant will be allowed to enter the fourth-year class as a candidate for a degree after October 15 in any year.

[1]By forwarding a copy of the diploma to the Secretary of the University, the holder of an Academic Diploma may learn to what extent the subjects covered by it will be accepted in lieu of entrance examination.

[2]When the candidate is at a considerable distance from the University, his application must be made earlier than September in order that he may receive the reply in time to present himself at the University on September 16, 1907.

The Committee on Admissions will notify the candidate by mail at the address given in his letter, between September 10 and 14, 1907, what courses, of those offered, are accepted as equivalent to courses at Columbia University. The Committee gives credit for complete courses only. In cases where the work previously done by the candidate has not been accepted by the Committee, the candidate may present himself for examination during the two weeks immediately preceding the opening of the University (in 1907, September 16-21), at the times and places at which the regular fall examinations are held. When no regular examination is held for the course at this time, the candidate may present himself for examination between the hours of 10 A.M. and 12 M. at the office of the head of the department giving the course. The schedule of fall examinations is to be obtained from the Registrar. A fee of $5 is charged for these examinations, to all applicants who do not take them at the regular time.

In cases where credit for part of a course might be given, the candidate will present his case to the chairman of the Committee on Admissions, at the times given above, for final adjustment. He should bring with him drawings, note-books, or other evidence showing the scope and character of the work for which he wishes credit.

Graduates of the Schools of Applied Science, and of other institutions of equal grade, may pursue any subjects taught in the schools for which they are properly qualified.

To Special Courses

Except for reasons of weight satisfactory to the Committee on Admissions no one will be admitted as a non-matriculated student who, within ten months of the time of his application, has been refused admission, or has failed in his work, as a candidate for a degree.

Persons who wish merely to pursue elementary subjects, such as may be offered for admission, are not received as non-matriculated students.

Persons of mature age who are not graduates, but who show special qualifications, are sometimes permitted to pursue special courses, but this permission is not given to others.

Non-matriculated students will be held to the observance of the same regulations as to attendance, examination, proficiency, and deficiency as matriculated students.

On Probation

Every first-year student admitted conditionally will be held under probation during the first half-year of residence. Not later than the end of this period, the Dean, on the basis of reports from the head of each department in which the student is registered, will decide whether he shall be admitted to full standing, have his period of probation ex-

tended, or be dropped from the roll. The mark of 7 or higher, obtained in any subject at the end of the first half-year of residence, will be regarded as removing an entrance condition in that subject, unless the condition was incurred in a part of the subject not directly involved in the work of the course. Any condition not so removed must be satisfied by formal examination.

REGISTRATION

Before attending any University exercises each student must register, *i. e.,* must present himself in person to furnish the information necessary for the University records and to file a statement of the courses he is authorized to pursue (for the matriculation or registration fee, payable but once, see below).

The office of the Registrar, 201 East Hall, will be open for registration from Wednesday, September 18, to Tuesday, September 24, 1907. New students may register also on Wednesday, September 25, 1907.

Students prevented, through no fault of their own, from completing their registration in due time, should file a provisional registration-record.

Registration at a later date is permitted only to candidates who obtain the written consent of the Dean, satisfactory cause for the delay having been shown. (For the fee for late registration see below.)

Credit for attendance will date from September 25.

Students holding scholarships are required to report themselves as in residence to the Registrar at the opening of each half-year.

Honorable Dismissal

In case of withdrawal during the academic year, students are requested to file a notice thereof with the Registrar, on a blank form provided for the purpose. An honorable discharge is always granted by the Dean to any student of good standing over twenty-one who may desire to withdraw, and, with the written assent of his parent or guardian, to a student under that age. Applications for leave of absence must be addressed to the Dean.

FEES

The President is under instructions to withdraw the privileges of any student delinquent in payment after the second Wednesday of each half-year. All regulations as to fees are subject to change by the Trustees at their discretion.

For Matriculation or Registration: Required of all students before entrance, payable but once............................	$ 5
For late Registration (see above)............................	5

For Tuition in the Schools of Mines, Engineering and Chemistry, payable at the beginning of each half-year; if the entire fee be less than $100 the whole must be paid upon registration.

For matriculated students for each half-year................ $ 125

For non-matriculated students, at the rate of $25 per annum for each hour of attendance upon lectures and recitations per week, with certain additional charges for laboratory work; the whole not to exceed $250 per annum.

For the use of the Gymnasium................................ 7

For Examinations, payable in each case before the examination is held:

For entrance (see p. 10 *et seq.*)........................ $ 5

For any examination or single series of examinations taken at any other time than at the conclusion of a course actually attended................................ 5

For any professional degree................................ 25

Laboratory Fees

Students not candidates for a degree, as well as all candidates for the higher degrees, are charged, in addition to the prescribed tuition fee, a fee for certain laboratory courses and for the use of laboratories, up to a maximum fee of $250, including tuition. The schedule of such fees may be obtained from the Registrar.

Summer Courses in Surveying

Laboratory fees, payable on or before the last Saturday in May, are required as follows: Civil Engineering course No. 15, $25, or $7 per survey; No. 25 and No. 27, $15, or $5 per survey; No. 26, $5; No. 28 and No. 71, $10.

Non-candidates, candidates for admission to, and students having entered with advanced standing, who may be required to attend these courses, and students required to repeat them through delinquency, are charged in addition tuition fees as follows: No. 15, $35; No. 25, No. 27, No. 28, and No. 71, $25; No. 26, $10; In the case of a student registered in Columbia College, who has paid an additional fee under the operation of this rule, an equitable credit will be made should he later complete the requirements for a professional degree.

For further details as to the administration of these fees, see the separately printed *Announcement of the Summer Courses in Surveying.*

Deposits for Apparatus Supplies and for Keys to Desks and Lockers

A deposit for the use of lockers, keys, apparatus, material, and the like, ranging from $2 to $40, is required of students in Applied Science.

At the end of the year each student will be credited with those articles which he returns in good order, and the value of those he has injured or broken will be deducted from his deposit. Details may be obtained from the Bursar.

Residence Halls and University Commons

(See page 96)

Scholarships

(See page 101)

Employment Committee

(See page 95)

Comparative Statement of Students' Probable Expenses for the Academic Year

	Low	Average	Liberal
Matriculation	$ 5	$ 5	$ 5
Gymnasium	7	7	7
Tuition	250	250	250
Books	30	45	60 up
Drawing material	2	10	15 "
Chemical apparatus	25	30	40 "
Room (37 weeks)	75	129	160 "
Board (37 weeks)	150	180	205 "
Clothes and laundry	25	40	75 "
College incidentals	2	5	25 "
Other expenses	10	25	75 "
Summer Courses in Surveying			
Tuition (1st and 2d year)	25	25	25
Travelling	5	5	5 up
Board (9 weeks)	63	75	100 "
	$724	$873	$1117

Summer Course in Mining—Fee, $50; other expenses, $200 to $250.

Summer Course in Geodesy—Fee, $20; other expenses, $20 to $25.

RULES GOVERNING STUDENTS

1. A student cannot be a candidate for more than one professional degree at the same time.

2. A candidate for a degree must comply with all requirements in force at the time said degree is conferred.

3. A student will be permitted to substitute one subject for another provided he obtains the consent of the Dean, the heads of departments concerned and the head of the department giving the technical instruction leading to the degree.

4. A student absent from more than one-tenth of the required exercises will be debarred from examination in that subject. Exceptions may be made by the instructor for reasons of weight when the absences do not exceed one-fourth the total number of exercises.

5. After examinations have been held, officers shall send to the Registrar a list of all students who have attended their courses, indicating proficiency by numbers on a scale of 10, a mark below 6 signifying a failure to pass. Students' records will be sent to them by the Registrar at the close of each year.

6. A student who has failed in any subject shall not be permitted to take advanced studies for which such failure indicates a lack of necessary preparation.

7. Regular examinations may be held at the end of the 1st and 2nd term or both, or at the completion of any course.

8. Special examinations for students debarred or deficient at regular examinations shall be held during the two weeks in September preceding the opening of the next following academic year; and for members of the fourth class in subjects belonging to that year only, during the first week in May. In all special examinations, a mark of 7 is required to pass.

9. The fee for special examination is $5, which must be paid before admission to examinations. If a student have special examinations in several subjects (during the same examination period), only a single fee of $5 shall be paid.

10. A student failing to pass in any subject at the regular examinations must present himself for special examination as provided under 8.

Failing to pass the second examination, he must repeat the subject with the next class. Failing a third time to pass a satisfactory examination he shall be dropped from the roll of the School.

11. Absence from any regular or special examination provided for in Rules 7 and 8 shall count as a failure unless excused by the Dean for reasons of weight.

12. A student shall be enrolled in the class in which the majority of his hours are taken; provided, however, that no student shall be advanced from the first to the second class who has entrance conditions aggregating 4 points; no student shall be advanced to the third class who has any entrance conditions or any deficiencies of the first year; no student shall be advanced to the fourth class who has any deficiency.

13. Any student who shall have passed a satisfactory examination in Columbia College in any subject forming a part of one of the professional courses in the School of Applied Science will not be required to pursue that subject a second time.

14. During vacations following the close of each year, memoirs on assigned subjects must be prepared by students in the courses of Metallurgy, Civil Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering, and Chemistry. The time specified for the completion and handing in of memoirs is the first Monday in November.

A student failing to hand in his memoir, drawings or other summer work shall be considered to have failed; to have his work received later, he will be obliged to pay a fee of $5, as for a special examination.

15. By permission of the Dean, and concurrence of the heads of departments concerned, a student may attend subjects not required for his degree, provided such attendance does not interfere with his regular work. He must fulfill all the requirements exacted from regular students in such course.

MINING ENGINEERING AND METALLURGY

Officers of the Department of Mining

Henry S. Munroe, E.M., Ph.D., Sc.D. .... *Professor of Mining*
Robert Peele, E.M. .... *Professor of Mining*
Edward L. Kurtz, E.M. .... *Instructor in Mining*
Walter R. Crane, Ph.D. .... *Instructor in Mining*

Officers of the Department of Metallurgy

Henry M. Howe, A.M., B.S., LL.D. .... *Professor of Metallurgy*
Bradley Stoughton, Ph.B., B.S. .... *Adjunct Professor of Metallurgy*
William Campbell, Ph.D., D.Sc. . *Adjunct Professor of Metallography*
Edward F. Kern, Ph.D. .... *Tutor in Metallurgy*
Cornelis Offerhaus, Ph.D. .... *Assistant in Metallurgy*

General Statement

The four-year course leading to the degree of Engineer of Mines is intended primarily to train men to undertake the development of mineral properties and to manage mines. The course includes substantial training in metallurgy. It is necessarily a broad one, comprising a wide range of studies in pure and applied science, and for this reason is frequently taken by students desiring a general scientific training.

In the fourth year students of mining have the option of omitting certain courses in Mechanical Engineering and Metallurgy, and taking in their place certain courses in Geology. This Geological Alternative is intended for students who expect to devote themselves to field-work in economic geology, or whose professional work is likely to be in new and less developed mining regions, and for other cases in which geological training may be of prime importance.

The four-year course leading to the degree of Metallurgical Engineer is intended primarily to train students to take charge of the administrative, manufacturing and testing departments of metallurgical works of all kinds. This course has much in common with that in Mining Engineering, but gives less attention to mechanical and mining engineering and more to chemistry and metallurgy. It is necessarily a broad course, covering a wide range of subjects in pure and applied science, and hence is well suited to those who seek a general scientific training.

The subjects most emphasized in these courses are mining, metallurgy, metallography, chemistry, geology, mineralogy, and engineering.

Mining and metallurgy require knowledge of inorganic and applied chemistry, qualitative and quantitative analysis, and assaying.

Metallography requires knowledge of physics and physical chemistry.

Geology must carry with it preliminary training in crystallography, mineralogy, and petrography.

Engineering in all its branches needs a fundamental knowledge of mathematics, physics, mechanics, and thermodynamics. The proper design and construction of mining and metallurgical plants involves the study of certain branches of civil engineering, and the many and increasing applications of machinery to mining and metallurgy make it necessary to give more and more attention to the theory and practice of mechanical and electrical engineering.

Advanced Students and Graduates can choose their subject and plan of work much more freely than undergraduates, and provided they work with foresight they gain by relying chiefly on their own resources.

The courses are severe, and should be undertaken only by those who are well prepared physically, mentally, and by previous training to devote themselves earnestly to the work required of them.

Situation of the School of Mines

Many coal, iron, and other mines, together with quarries and metallurgical works, are easily accessible from New York in from one to four hours by rail. Among these are magnetic iron mines in New York, New Jersey, and Pennsylvania; hematite mines and stone quarries in the same states, and in Connecticut; anthracite and bituminous coal mines, and natural gas and oil wells in Pennsylvania, and zinc mines in New Jersey and Pennsylvania. New York and the adjacent states produce each year about half the pig-iron and coal, and over forty per cent. of the total value of the mineral product of the whole country. There are within easy reach of New York City iron blast furnaces and some of the most skilfully arranged and managed steel works, rolling mills, steel and iron foundries, copper smelting and refining works, lead refining works, zinc works, and electrolytic establishments in the world. New York City, moreover, is the headquarters of many corporations operating mines and metallurgical works in this and other countries. Within a radius of one hundred miles may be studied many phases of the best practice in mining and metallurgy in the country. By going a little farther one may reach the bituminous coal fields and the natural gas, oil and salt regions in one direction, and the pyrite deposits, and granite and marble quarries of New York and New England in the other; while the excursions of the summer class in mining extend as far as the copper, iron, zinc, lead, silver, and gold regions of Michigan, Missouri, Montana, Colorado, California and Utah.

The metropolitan situation of the school enables it to present, also, as parts of the regular courses in mining and metallurgy, special lectures by eminent engineers and metallurgists. The list of such lecturers in previous years is given on page 6.

Building

The New School of Mines Building—Through the generosity of Mr. Adolph Lewisohn a new building was given in 1905 for the School of Mines for the use of the departments of mining and metallurgy. The new School of Mines building is 145 feet long by 57 feet in width and four stories in height, with basement and sub-basement, or six floors in all. The basement and sub-basement contain the ore-dressing laboratories. In the center of the building on the main floor, and on either side of the entrance hall, are the mining and metallurgical museums. At the north and south ends of the building are the lecture rooms, opening out of the museums. On the second floor are the offices of the department of mining, the mining and metallurgical department libraries, a drafting-room for the design work of the fourth year, and one of the metallurgical laboratories. On the third floor are the offices of the department of metallurgy, the furnace rooms, the chemical laboratory, metallographic laboratory, and the research laboratories of the same department. The fourth floor contains three drafting-rooms and the offices of the instructors in charge.

EQUIPMENT

Department of Mining

Lecture Illustrations—The lectures on mining are illustrated by 5 sets of books aggregating over 300 volumes, and containing 85,000 blue prints from negatives made for the purpose. There are a sufficient number of these books, illustrating the different courses of lectures, to allow each student the use of one or more for reference during the lectures, and for home study. These blue prints have many advantages over the usual form of lecture illustrations by lantern slides or wall diagrams. The latter are, however, used when necessary to supplement the blue prints.

Mining Library—The University library contains complete sets of the transactions of all mining, metallurgical, and engineering societies, and of the more important periodical publications on these subjects. There is also a large collection of books on mining, and all new publications of value are added as they appear. In addition, a small departmental library has been created, which is accessible to students at all times.

Mining Museum—The subject of mining is illustrated by collections.

as follows: Maps of coal and metal mines of this and other countries. Working drawings, diagrams, and photographs of mine plant, and of mining and dressing machinery. Models of mines and parts of mines, and of mine plant. Mining tools: picks, shovels, hammers, drills, blasting apparatus, lamps, safety-lamps, anemometers, hand-power and machine drills. Ores and dressing products from typical works in this and other countries. Surveying instruments: geological compasses and clinometers, attraction compasses, dipping needles, hanging compasses and arcs, transits, lamp signals, rods, and apparatus for plumbing and measuring shafts.

Among the more notable exhibits are large relief models of two mines of the Cleveland-Cliffs Iron Mining Co. of Michigan, a similar model of a typical gold mine in Colorado, and a set of three glass models and two relief models of the Copper Queen Mine in Arizona, a model of the mine workings in the Mahonoy and Shenandoah anthracite coal basins, Pennsylvania, a glass model of the mine workings on the Calumet Conglomerate of Houghton County, Michigan, a model of a standard oil-well drilling rig, and a model of the St. Joseph Lead Co.'s dressing works at Bonne Terre, Missouri.

A collection of working drawings of mine plant, and a large collection of underground photographs, taken by magnesium light, are worthy of special notice.

Mining Laboratories—Seven rooms in the basement and sub-basement of the Engineering Building are equipped as laboratories for the department of mining. These laboratories serve to supplement the study of ore concentration and milling made by the student as a part of the regular work of the Summer School of Mining, and in particular afford him facilities for such study that cannot well be given him at the works. They include the following:

The Laboratory for Mechanical Assays contains appliances for quantitative work in hand picking, jigging and vanning small samples of ore, and for panning gold-bearing gravel. For small scale working tests there are a number of specially designed laboratory classifiers, laboratory jigs, laboratory slime tables, and apparatus for tests by amalgamation and by acid and oil flotation processes. A small laboratory magnetic concentrator is under construction.

The Crushing and Sampling Laboratory contains machinery for crushing and sampling large and small lots of ore, including a small Gates crusher, a Krom high-speed jaw crusher and Krom high-speed rolls, a sample grinder, ball and pebble mills for fine crushing, gyratory screens, a Vezin automatic sampler, and laboratory crushers, together with sieves, riffle samplers, etc.

The Laboratory for Working Tests contains a small power jig, a buddle, a keeve, and other similar apparatus for working a ton or more of ore at a time.

The Laboratory of Dressing Machinery contains full-sized machines of standard types, each arranged so that the products, heads, middlings and tailings are returned at once to the same machine for re-treatment. With a small quantity of ore each machine can thus be operated as long as may be necessary, and the student is afforded an opportunity to become familiar with the adjustments of the machine and the tests of proper and successful working. The apparatus now installed includes three Harz jigs of two, three and five compartments, a Hooper air jig, two round tables, concave and convex, a Frue vanner, a Wilfley table, and a Stein-Bilharz belt table. On the lower floors are full-sized classifiers, settlers, automatic feeders, and centrifugal pumps for supplying these machines with water and ore for continuous work.

Department of Metallurgy

Lecture Illustrations—There is a collection of lecture diagrams, illustrating metallurgical furnaces and appliances, and showing graphically the sequence of operations in many metallurgical processes. In addition the lectures are illustrated by the models referred to below and by actual demonstration, as for instance in the heat-treatment of metals, in the wet metallurgical processes, in the rolling of metals, for which purpose a small roll-train is used, and in other like ways.

Models and Drawings—These include models of metallurgical apparatus, furnaces, Bessemer converters, roll-trains, etc., and a large number of working drawings, additions to which are constantly being made.

Metallurgical Collection—This is intended for educational and laboratory purposes and for illustrating the lectures and contains about 3,000 specimens of ores, slags, metals, fuels, refractory materials, and the intermediate and final products of the more important metallurgical processes. Its value is increased by labels explaining the particular principles illustrated by the individual specimens and suites.

Metallurgical Laboratories—Of these there are three: One for non-ferrous metallurgy, electro-metallurgy, and wet metallurgy (Mines Building No. 401 and Havemeyer Hall No. 101); one for ferrous metallurgy (Mines Building No. 501), and one for metallography (Mines Building 505, 506 and 507).

These laboratories serve four chief purposes: (1) to give skill in the use of the instruments of precision of the art; (2) to teach the underlying principles of metallurgy and give familiarity with the conditions, especially as to high temperature, under which metallurgical operations must be carried on and the use of the principal types of furnaces and other metallurgical apparatus, or in short "Analytical metallurgy"; (3) to give some acquaintance with certain industrial metallurgical processes, or what may be called "Applied metallurgy"; and (4) to give

advanced students the means of making metallurgical and metallographical researches.

The Instruments of Precision. These include especially the calorimeter, microscope, and pyrometer. Throughout the laboratory furnace work the student is required to control the temperature of his operations with the Le Chatelier pyrometer. Among the Le Chatelier pyrometers are some fitted for industrial use with galvanometers of the Siemens-Halske type, and others of greater delicacy with galvanometers of the Carpentier type. Records of temperature can be taken with the Roberts-Austen apparatus or with an autographic instrument developed in this laboratory. The former records continuously the temperature of any three furnaces or other points under observation. There are also pyrometers of the Wanner optical, Féry radiation, Le Chatelier photometric, Mesuré and Noel (Ducretet) optical, Siemens calorimetric, and other types. There is a supply of ammeters and voltmeters for controlling the electric furnaces and operations; and of sclerometers of different types for measuring the hardness of metals, etc.; together with a drop-testing apparatus for testing the physical properties of metals and alloys; a Mahler-Berthelot calorimeter for testing the calorific power of fuels, etc., and many other instruments.

The metal working shop of the department is equipped with power driven machines for cutting specimens, etc.

Most of the furnaces are gas-fired, and those furnaces which are intended for precise work are heated by electric resistance.

NON-FERROUS AND ELECTRO-METALLURGICAL LABORATORY. *A. Wet and dry metallurgy.* This laboratory is well equipped for studying, both by analytical and by applied metallurgy, the extraction, refining and alloying of the non-ferrous metals, especially those of commercial importance. There are two gas-fired ore-roasting furnaces; a cupola furnace for smelting the ores of copper and lead; an "English" cupelling furnace for cupellation, bringing forward copper matte, and refining black copper; two 10-inch and one 18-inch gas-fired crucible furnaces; three assay muffle furnaces; one forge for high temperature work, such as determining the melting points and behavior of slags; two cyanide plants; a small filter press; a set of amalgamating pans; a gold-ore chlorinating barrel; two small Parke's desilverization kettles, etc., besides the instruments of precision.

B. Electro-metallurgy. For studying the electrical recovery, deposition, and alloying of metals there is a good equipment which consists of a battery of storage cells; a switchboard for connecting the cells in any desired combination; vats for electrolytic refining; electric furnaces of the Moissan arc, the Borcher and the wire-resistance types.

IRON AND STEEL LABORATORY—The gas furnaces include two double muffle furnaces especially designed for this laboratory, in which many full-sized tensile test bars may be heated to any temperature up to

1300° C., with uniformity and precision; a 7-inch crucible furnace in which cast iron can be melted; one square and three circular gas forges, used especially for heating steel for rolling, heat-treatment, etc.; a small muffle for heating out of contact with the air and furnace gases; and portable gas furnaces. A forced-draft, coke-fired, crucible-furnace is building.

There is a large electric resistance muffle, designed specially for this department, 50 inches long and 2 inches in diameter, in which full-sized test pieces can be heated with great accuracy; and hand-driven rolls, and a small power-driven roll-train, for studying questions like the influence of reduction and of finishing temperature on the properties of metals.

THE METALLOGRAPHIC LABORATORY is well equipped for the microscopic and pyrometric study of metals, mattes, slags, etc., a subject in which every student in metallurgical engineering has to get some skill. For the pyrometric work there are many electric-resistance furnaces of the Heraeus, Howe and Sauveur types, and portable gas furnaces. For the microscopic work there are six microscopes of the Leitz, two of the Le Chatelier, one each of the Swift and Beck types, and others for the examination of opaque bodies; an excellent equipment for illumination, photography, etc.

ANALYTICAL LABORATORY—This is open to students in metallurgy for making chemical analyses in connection with metallurgy. Analytical chemistry is not taught here, but in the Department of Chemistry.

SUPPLIES—There is a large stock of ores, irons, steels, alloys, refractory materials, fluxes, etc., which may be used for investigations.

METALLURGICAL LIBRARY—This contains about fifteen hundred volumes of metallurgical treatises, text books, periodicals, etc. The library is open to all students, and to other persons properly introduced, and books may be borrowed under suitable restriction.

METHODS OF INSTRUCTION

The instruction in the School of Mines during the first and second years includes the necessary fundamental training in mathematics, physics, mechanics, chemistry, mineralogy, and geology above outlined. Surveying and engineering drafting begin with the first year.

The chemical laboratories for qualitative and quantitative analysis and assaying, the mineralogical and geological laboratories, the physical laboratories, and the drafting rooms are among the best in the country. Laboratory instruction in chemistry, assaying, drafting, mineralogy and geology extends through three years, the latter including microscopic work on thin sections of minerals and rocks. This training not only fits the student for subsequent studies, in his professional practice, of the phenomena of ore deposition, but also furnishes an

admirable introduction to the microscopic study of metals and alloys, which is included in the required work in the metallurgical laboratory.

In the engineering, mining, and metallurgical laboratories the student continues the work begun in the chemical and physical laboratories, and is given opportunity for the experimental demonstration of the physical, mechanical or chemical laws and general fundamental principles underlying any given branch of engineering. These laboratories are also equipped to train the student in the making of scientific tests of engineering materials, and working tests of machines and processes of ore treatment; thus preparing him, as far as it is possible in the school, for work that he will be called upon to do as an engineer.

Practical instruction in summer classes in the field is made an important feature of the curriculum. Details of the summer courses in mining, metallurgy, field geology and surveying will be found on pages 29-31.

While much time is thus given to practical training in the laboratories, in the field, and at the mines and metallurgical establishments, care is taken to subordinate this instruction to the regular classroom work, and especially in subjects which are fundamental. In all such subjects a high standard of accomplishment is rigorously maintained.

Mining Laboratory Instruction

The work required in the mining laboratories is designed (1) to illustrate the physical laws and practical conditions affecting the mechanical concentration, separation, and purification of minerals; (2) to instruct the students in the details of quantitative working tests on both small and large scale; (3) to train them in the adjustment and operation of the standard types of concentrating machines, and in testing the efficiency of such machinery in actual operation, and (4) to give opportunity for original research.

The work includes the reduction of a ton or more of ore to laboratory samples, and tests on portions of this ore by handpicking, hand jigging, and mechanical treatment on laboratory jigs, classifiers, and slime tables, to determine the proper method of mill treatment. These tests are controlled by crushing and vanning samples of the products, and reports of the results obtained are made in a systematic manner.

The large concentrators are arranged to be run continuously, for as many hours as may be necessary, using the same ore and the same water again and again. This is accomplished by running the products of the several machines through dewatering cones, from which the mixed material is transferred to the hoppers of automatic feeders. Variable speed pulleys permit any desired adjustment of the driving mechanisms. The water supply is drawn from a constant level tank fed by

a centrifugal pump, and is regulated by dial cocks. Other adjustments are equally under control and can be varied at will.

With each of these machines the student makes a series of experiments designed to bring out the physical laws governing successful working, to afford instruction in the practical details of operating the machines, and to give opportunity for engineering tests of capacity and efficiency under different conditions of treatment. These include the adjustment and regulation of the ore supply, of the feed and wash water, of speed, stroke, and other working conditions to the treatment of different ores and different grades of sand and pulp. In this work the student is taught to recognize the symptoms of irregular working, to diagnose the trouble with the aid of laboratory tests, and to apply the proper remedy. Incidentally he makes tests of capacity and efficiency, taking frequent samples of the ore feed, and of the different products for quantitative examination, and weighs and measures the ore and water supply and products obtained.

Experiments of this kind for purposes of instruction cannot well be made at concentration works in the field. Here the machines must work regularly and without interruption, and any interference with the ore feed, water supply, or other adjustments may occasion loss of valuable mineral.

RESEARCH WORK—The equipment of the mining laboratories includes necessary facilities for original investigation in the physical laws controlling the mechanical treatment of minerals.

The following titles indicate some of the lines of original research undertaken by graduate students in recent years:

Investigation of Magnetic Fields with Reference to Ore-Concentration.

The effect of variations in the speed of crushing machinery on the production of undersized material.

The amalgamation of gold ores.

Mining Thesis

The subjects for the graduation theses are assigned in the spring and summer preceding the final year of the mining course, and are made a part of the regular course of instruction. The subject given in each case is the problem of the opening and development of a mine, which is supposed to be located in some well-known mining district, and for which certain definite conditions as to size and character of ore body, amount of water to be pumped, and quantity of ore to be mined, are assumed. During the summer the student visits the assigned region and studies the conditions under which mining is there conducted, thus obtaining data for his thesis work. The information thus acquired is supplemented by study of the books and technical litera-

ture dealing with the subject. During the fourth year he decides upon the proper methods for opening, developing, and working the property; and makes estimates of the plant machinery and capital required, the cost of working, and the probable profits. He is also required to work out in detail certain portions of the proposed mine plant, and to prepare a set of working drawings, bills of materials and specifications therefor. This work and the preparation of the thesis is done under the supervision of competent instructors, and constitutes both a review and a series of practical applications of the preparatory studies of previous years. It enables the students to discover and remedy their weak places and gives them some degree of confidence in their ability to work out similar problems later.

DEPARTMENT OF METALLURGY

The instruction may be divided into two parts, the undergraduate and the graduate.

The undergraduate instruction consists of (1) class-room work, lectures, conferences, study of text-books, etc. (see p. 41); (2) general laboratory work in metallurgy (see p. 43); (3) training in planning and executing original research; (4) summer courses and other visits to industrial metallurgical works (see p. 43).

The *graduate instruction* consists primarily of original research either in the departmental laboratories, in industrial works, or by study (see p. 44).

Metallurgical Laboratory Instruction

In order to become familiar with a wide range of the conditions and principles of metallurgy, the student makes many experiments, each illustrating, testing, or aiming to discover some one or more metallurgical principles or reactions, or the conditions which permit a given reaction to occur. He must, in general, after each experiment enunciate briefly in writing the law to which his results point, or indicate how far those results severally and collectively support or oppose a given proposition.

These experiments relate chiefly to such subjects as the influence of thermal treatment on the properties and microstructure of metals and alloys, especially iron and steel; the determination of melting points and other temperatures; the relation between the composition of slags and their fusibility; the influence of fluxes; the behavior of refractory materials at high temperatures, either alone or in contact with different slags; the temperature limits and the reactions of roasting operations; the influence of various bodies on the reactions which take place in roasting, in the cyanide process, in the chlorination process and in pan

amalgamation; the interaction of carbon and molten oxides, sulphides, silicates, etc., etc.

The Art of Investigation (Course 176). There is a demand, which cannot now be filled even by importation, coming from the makers of steel and of certain alloys, for young metallurgists to make original investigations especially in metallography. Fitness for such places requires knowledge not only of metallurgy but also of the art of investigation itself.

To acquire this, the student has to reduce to precise terms a series of problems which are given him purposely in vague form; and to plan and specify systematically the experimental procedure for solving them. He then executes an investigation thus planned, and, in his graduating thesis, describes his experiments and results in detail, summarizes them in tables and diagrams, and shows briefly and clearly what their answer to his problem is, specifying which of them support and which oppose each definite proposition.

SUMMER COURSES

Summer Courses in Surveying—These courses are conducted during fourteen weeks of the summer vacations at a large farm owned by the University near Litchfield, Conn. About six weeks attendance is required of each class between the first and second years, and eight weeks between the second and third years. A fuller statement with regard to this work will be found on page 46.

Summer Courses in Practical Mining—The scheme of instruction includes six to eight weeks, spent in detailed study of the plant and methods of working at some mine or mines; in geological work, surface and underground; in mine surveying, and in excursions to other mines and mining regions. These summer courses are under the supervision of one of the Professors of Mining and the other members of the staff of the Department of Mining. The course of study includes shaft-sinking, drifting, stoping, timbering, underground haulage, hoisting, mine drainage, ventilation, surface plant, mine buildings, repair shops, houses, etc., water supply, organization, administration, and underground surveying. The students are divided into small squads, and assigned each day to a foreman, or working gang of miners, for the study of some definite subject. Each squad of students is visited several times during the day by the instructor, who examines their work and indicates subjects demanding special study and observation. Manual labor and the acquirement of manual dexterity by the student are subordinated to the development of his powers of observation, and to the careful study of the work going on about him, and the recording of his observations and study in notes and sketches taken on the spot. The students' note-books are examined and criticised each

evening. By thus systematizing and directing the work of the student his time is economized, and the work done more thoroughly. Arrangements are also made at other mines, by which the students, singly or in small groups, may substitute for the class-work described above independent study, according to a definite plan and under the general direction of the department.

These summer courses have been in operation since 1877, and have proved themselves an indispensable adjunct to the regular curriculum. They bear the same relation to the study of mining as laboratory work to the study of chemistry or physics, or clinical instruction and hospital practice to the study of medicine.

In 1905, the summer session was held at the Richard, Hurd and Mount Hope iron mines, near Dover, N. J., and the Maltby, Prospect, Drifton, Oneida and other collieries, in the anthracite fields. The larger part of the class was sent out in separate squads, without instructors, to certain gold, silver, copper and iron mines, chiefly in the West, at which arrangements were previously made and the necessary privileges secured. Among these mines were the Daly West, Utah; Baltic and Aragon, Michigan; Camp Bird, Colorado, and the properties of the Tennessee Copper Co. and the Copper Queen and Arizona Copper Co., of Arizona.

In 1906, a small division of the class studied in the mines of the Michigan copper region. The detail work, occupying four weeks, was done in the Wolverine mine. Short visits were then made to the Mohawk and Trimountain copper mines, and the surface plants of mines in the vicinity. The last week was spent at several iron mines of the Marquette district. As in 1905, the greater part of the class was distributed in small parties for study at a number of mines in the West, among which may be named the North Star, California, the Independence, Colorado, and the Bunker Hill and Sullivan, Idaho.

Summer Courses in Metallurgy—There are two courses, Nos. 62 and 64, which consist of studying and reporting on industrial processes at metallurgical works. The students receive individual and class instruction, and have to make complete descriptions of the processes, with dimensioned sketches of furnaces and other apparatus. Course 62 has to do with copper, lead, gold, silver and zinc works, and is compulsory for one week for students in mining engineering and for three weeks for students in metallurgical engineering. Course 64 has to do with iron and steel works, and is optional for one week for students in mechanical engineering and compulsory for three weeks for students in metallurgical engineering. The latter students may, under certain restrictions, replace two weeks of each of these two courses with actual employment in metallurgical works. In this case they must report on their experience, with full descriptions of processes and apparatus, and

with analyses or dimensioned drawings of both. The visits to iron and steel works are generally made in Pennsylvania; those to non-ferrous works are sometimes in the west—sometimes in the east.

In 1903 and 1904 one week was spent in visiting the metallurgical works at Denver, Colorado City, Pueblo and Florence, Colorado. The work in iron and steel was performed at the Carnegie Steel Company's works near Pittsburgh in 1903, and at the works of the Pennsylvania Steel Company and the Central Iron and Steel Company, Steelton, Pa., in 1904, and at several iron and steel works in the vicinity of Pittsburgh in 1905. In 1905 and 1906 the non-ferrous summer school visited copper, lead, gold, silver and zinc works in the vicinity of New York City.

In addition to these courses the students visit several iron and steel works in the neighbourhood of New York during the Easter vacation. This visit is optional for all students who are taking, or have taken, Metallurgy 2b or 4.

Summer Courses in Geology—In connection with the summer courses in practical mining, at least one week is devoted to practical field geology. The class is instructed in methods of field observation, locating outcrops, measuring dip and strike, keeping notes, etc., and afterwards are required to construct maps and geological sections from the observations noted. This instruction is given under the immediate supervision of the Professor of Geology.

Metallurgical and other Excursions—During the term the students are taken to various metallurgical establishments, and may visit different mines, foundries, machine shops, electrical establishments, and points of geological interest in the city and its environs. Excursions for this purpose are frequently organized by the different departments.

In the regular Summer Session held at the University in July and August of each year many courses of interest to engineering students are offered. The *Announcement of the Summer Session* will be sent upon application to the Secretary of the University.

Other Departments

Information as to the equipment available to students of Mining and Metallurgy in other departments of the University is to be found in this pamphlet as follows:

COURSES IN MINING

Underground Courses

51—Excavation and Tunneling—3 hours, first half third year. Professor Peele

Excavation of earth: tools and methods employed, support of excavations, special methods for quicksand and other water-bearing material; steam shovels and other mechanical excavators; handling and transportation of excavated material; comparative costs. Explosives: black powder, nitro-glycerine and its compounds, and other high explosives; their composition, manufacture, and use. Excavation of rock: methods of drilling and blasting, mammoth blasts, submarine blasting. Quarrying: plant and methods for quarrying different rocks. Railroad tunnels: methods of driving and timbering; handling and transportation of excavated material; drainage and ventilation; lining of tunnels; submarine tunnels. Mine tunnels; examples from practice; sizes, details of driving, timbering, speeds of advance and costs.

Required of students in the course of Mining Engineering

Pre-requisites: Entrance requirements in Mathematics, Chemistry, and Physics

52—Boring and Shaft Sinking—2 hours, second half third year. Professor Peele

Boring: methods and appliances for small depths and for deep boring; rod boring and cable tool or oil-well method; boring with diamond drill, for prospecting and other purposes; survey of bore-holes. Shaft sinking: methods and tools employed in soft material and in rock; sinking linings or drop-shafts, freezing and other special methods of sinking in water-bearing formations and quicksand; drainage of shafts; handling and hoisting of excavated material. Shaft timbering, walling, tubbing, and other modes of lining.

Required of students in the course of Mining Engineering

Pre-requisite: Mining 51

54—Exploration, Development, and Methods of Working—3 hours, second half third year. Professor Munroe

Mineral deposits, characteristics of beds, masses, veins, and other deposits, and the irregularities and disturbances to which they are subject, as affecting the work of exploration and mining. Examination and survey of mineral properties; relation of topography to geological structure; construction of maps and sections; and tracing of probable outcrops as a guide to exploration. Prospecting by ditches, pits, and deep boring. Development; choice of methods; location of openings. Working of deposits and support of excavations; theoretical considerations, methods of breaking ground in coal and metal mining, and support

of mine excavations by pillars of mineral, by timbering, by masonry, and by rock filling; methods of working applicable to deposits of different thickness, inclination, and character. Coal mining; vein mining; working of thick deposits and soft-ore bodies. Salt mining. Surface workings. Hydraulic mining and gold dredging.

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisites: Geology **103-104**. Pre-requisites or parallels: Geology **105-106**, Mining **51** and **52**

Counts, together with Mining **81-82** and **82a**, or with Mining **56**, **55**, and **91-92**, as a minor for the degree of A.M.

81-82—ORE DRESSING, MILLING, AND THE MECHANICAL PREPARATION OF COAL—2 hours, fourth year. Professor MUNROE

The general principles and theory of dressing; preliminary operations; hand dressing; cleansing; crushing; jigging with and without preliminary sizing; slime concentration; magnetic and electro-static separation; oil and flotation processes; milling of gold and silver ores; descriptions of typical dressing works and coal-washing plants in this country and abroad.

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisites: Mineralogy **1-2**, Physics **3-4**. Pre-requisite or parallel: Mechanics **9**

Counts, together with Mining **54** and **82a**, or with Mining **82a**, **70** and **75**, as a minor for the degree of A.M.

82a—ORE-DRESSING LABORATORY—Afternoon work for three weeks, second half fourth year. Professor MUNROE, Mr. KURTZ and Dr. CRANE

Mechanical testing of ores by laboratory methods; working tests with simple apparatus; adjustment and operation of concentrating machines

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisite or parallel: Mining **81-82**

Counts, together with Mining **54** and **81-82**, or with Mining **81-82**, **70** and **75**, as a minor for the degree of A.M.

56—MINE ENGINEERING—2 hours second half fourth year. Professor MUNROE

Surface handling and transportation; arrangements for loading and unloading cars and vessels, and for storing of minerals. Mineral railroads. Common roads. Drainage: sources of mine waters; methods for the control and raising of water; dams; drainage levels. Water supply. Ventilation; air of mines; mine gases; methods of ventilation; control and measurement of air currents. Accidents to men in shafts, levels and working places; fire-damp and dust explosions; mine fires; inundations; rescue and relief of men

Required of students in the course of Mining Engineering

Pre-requisites or parallels: Mining **54** and **71-72**, Civil Engineering **76** and **28**

Counts, together with Mining **54**, **55** and **91-92**, as a minor for the degree of A.M.

71-72—MINE PLANT—3 hours, fourth year. Professor PEELE

Descriptions and critical discussion of the machinery and appliances employed in the equipment of mines; design, erection and care of plant. Hoisting: engines, drums, wire rope, skips and cages, head-frames; calculation of power required and methods of equalizing the load on the engine; shaft-sinking plant, over-winding. Drainage: buckets, tanks and hand-pumps; Cornish and direct-acting underground pumps; operation of pumps by electricity, compressed air, and hydraulic power. Centrifugal pumps. Ventilation: natural ventilation, underground furnaces, positive blowers, and centrifugal fans; theory and efficiencies of fans. Air compressors: straight-line and duplex; simple and compound (stage) compression; methods of dealing with heat of compression; conveyance of compressed air in pipes; reheating; operation of machinery by compressed air; efficiencies. Machine drills: their construction and operation. Coal-mining machines or coal-cutters. Handling mineral in working places. Mine cars: arrangement and construction of tracks. Underground haulage; hand tramming; mule haulage; gravity roads; steam, compressed-air, and electric locomotives; rope haulage; efficiencies; comparison of systems of haulage

Required of students in the course of Mining Engineering

Pre-requisites: Mining **51**, **52** and **54**, and Mechanical Engineering **69**. Parallels: Mechanical Engineering **13** and **14**

Counts, together with Mining **70** and **75**, as a minor for the degree of A.M.

70—MINE CONSTRUCTIONS—1 hour, second half third year. Professor PEELE

Building-stones; bricks; limes; cements and concretes. Foundations in various soils; retaining walls; masonry and timber construction, with special reference to mine work; mine buildings; trestles; ore-bins

Required of students in the courses of Mining and Metallurgical Engineering

Counts, together with Mining **71-72** and **75**, or with Mining **81-82**, **82a** and **75**, as a minor for the degree of A.M.

75—DESIGN OF MINE PLANT—5 afternoons first half fourth year. Professor PEELE, Mr. KURTZ and Dr. CRANE

The students are assigned problems in the design and construction of mine plant, in connection with the development of a mine. This work supplements the lectures on the design of mining machinery, involving reading and study, and the preparation of working drawings, covering certain portions of the plant, together with bills of material, specifications, and estimates. As these drawings are intended to accompany and illustrate in part the graduating theses or projects, the designs are made in accordance with the subjects and conditions assigned

to each student. The work is done under constant supervision and advice in the draughting-room

Required of students in the course of Mining Engineering

Pre-requisites: Mechanical Engineering **3-4**, **7-8**, Civil Engineering **53-54**. Parallel: Mining **71-72**

Counts, together with Mining **71-72** and **70**, or with Mining **81-82**, **82a** and **70**, as a minor for the degree of A.M.

55—Mine Surveying and Mine Examination—1 hour for three months, first half fourth year. Professor Munroe

This course supplements the practical work in underground surveying in connection with the summer school in mining. It includes the general principles of underground surveying, the construction of mine maps and sections, and of models of mine workings, the measurement of contracts, the location of lines for new work; examination, sampling, and valuation of mines

Required of students in the course of Mining Engineering

Pre-requisites: Civil Engineering **1-2**, **15**, and **27**, and Mining **54**

Counts, together with Mining **54**, **56** and **91-92**, as a minor for the degree of A.M.

91-92—Administration and Mine Accounts—1 hour, fourth year. Professor Munroe and Mr. Kurtz

Administration, organization, and business management, mine accounts, and cost sheets

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisite: Mining **54**. Parallel: Mining **56**

Counts, together with Mining **54**, **56** and **55**, as a minor for the degree of A.M.

77-78—Graduating Thesis or Project—Professor Peele

Required of students in the course of Mining Engineering

Pre-requisites or parallel: All the required courses in Mining

80—Mill Constructions—Installation and operation of mechanical power transmission and auxiliary machinery in works for the mechanical treatment of minerals. Dealing with shafting, bearings, pulleys, belting, rope drives, gearing, etc. 1 hour, second half third year. Mr. Kurtz

Pre-requisite: Mechanical Engineering 69

94—Mining Law—2 hours, second half fourth year. Mr. Kurtz. General principles of real estate law. Historical review of mining laws of various countries. Federal laws, concerning locations on public lands of the United States. State and territorial mining laws

Pre-requisites: Civil Engineering 27, Mining 54

95—Mining Conference—1 hour. Dr. Crane. (Optional.) Reading and discussion of papers by the students, on mining practice and based on data accumulated in the course of the summer work in mining

Summer Courses

59—The Summer Courses in Practical Mining are held in June and July, at some mine or mines selected for the purpose, in the vacation between the third and fourth years, and last six to eight weeks, including one week field geology (for details see pages 29-31). Professor Peele, Mr. Kurtz and Dr. Crane

Pre-requisites or parallels: Mining **51**, **52** and **54**, Civil Engineering **15**, **16** and **17**, Mechanical Engineering **69** and Geology **105-106**

Graduate Courses

Special courses, consisting of personal instruction, reading, and experimental investigation, will be arranged for advanced students according to their individual needs and ability. These investigations will be made at mines and dressing works either in connection with the Summer class or elsewhere as assigned, with additional work, as required, in the library and in the laboratories of the department. These courses vary in difficulty and in the amount of time necessary, according as the student is a candidate for the degree of A.M. or Ph.D., and according as he pursues mining as a major or a minor subject. The time required is governed by the rule that a course or courses should occupy about 18 hours (outside reading and study included) per week if taken as a major subject, and about 9 hours per week if taken as a minor subject. The following are suggested:

101-102—Mining and Ore Dressing—Mining 54, 81-82 and 82a. 4 hours, with laboratory work and reading as required

Pre-requisites: Mining **51** and **52**. Count together as a minor for the degree of A.M.

103-104—Mining Engineering—Mining 54, 56, and 91-92. 3 hours lectures and reading as required

Pre-requisites: Civil Engineering **53-54** and Mining **51** and **52**. Count together as a minor for the degree of A.M.

105-106—Design of Mine Plant—Mining 71-72, 70 and 75. 3 hours and 5 afternoons draughting-room work

Pre-requisites: Civil Engineering **53-54**, and Mining **51**, **52**, and **54**. Count together as a minor for the degree of A.M.

107-108—Design of Ore-dressing Works—Mining 81-82, 82a, 70 and 75, with 1 hour conference additional first half-year. 3 hours, and 5 afternoons laboratory and draughting-room work

Pre-requisite: Civil Engineering **53-54**. Count together as a minor for the degree of A.M.

109-110—Mining—All the undergraduate courses in the department of Mining

See regulations for higher degrees.

201-202—Methods of Mining—Critical study of methods used in some mining region, or for a certain class of deposits; output per man, amount of timber and explosive required, and other details affecting cost. Study of conditions as determining choice of method. Determination of loss of mineral in mining. Accidents to men

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

203-204—Mining Plant—Critical study of rock drilling, or coal cutting, or hoisting, or haulage, or ventilating plant at some mine or mines. Determination of efficiency and conditions affecting same

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

205-206—Deep Mining—Study of problems of deep mining, vertical versus inclined shafts, hoisting and pumping from great depths, temperature and ventilation, efficiency of labor, rock pressure as affecting methods of mining and timbering

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

207-208—Ore Dressing—Critical study of some detail of the ordinary dressing methods, crushing, or screening, or classification, or jigging, or slime treatment, or dry concentration, or magnetic separation, or milling of gold or silver ores, or mechanical preparation of coal. Determination of efficiency, and of conditions essential to success

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

209-210—Examination of a Coal-washing Plant, or of an Ore-dressing Plant—4 to 6 weeks work in the mill and in the laboratory, with conferences

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

211—Examination of a Mineral Property, or a Mine—4 to 6 weeks devoted to field and underground work in the summer school of practical mining, with conferences at convenience of professor

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

213-214—Economic Studies in Mining—Study of existing conditions affecting the production and cost of some mineral or metal, as, for example, anthracite coal, copper, or gold

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

PROGRAM OF STUDY IN THE COURSE OF MINING ENGINEERING

First Class	Page No.	Second Class	Page No.	Third Class	Page No.	Fourth Class	Page No.
General inorganic chemistry (Chem. 3-4)	75	Quantitative analysis (Chem. 66)	78	Resistance of materials (C. E. 53-54)	48	Hydraulics (C. E. 76)	50
Qualitative analysis (Chem. 61-62)	77	Industrial chemistry (Chem. 81-82)	80	Testing laboratory (C. E. 55-56)	......	†Index fossils of North America (Geol. 16)	88
Spherical trigonometry (Math. 2)	91	Theory of railroad surveying (C. E. 23)	47	Graphic statics (C. E. 64)	49	Geological examinations and surveys (Geol. 110)	89
Analytical geometry (Math. 3-4)	91	Elements of electrical engineering (E. E. 1)	56	Principles of electrical engineering (E. E. 68)	57	†Petrology (Geol. 201-202)	89
a Elements of mechanical drawing...... Freehand lettering.. *b* Projections......... *c* Machine drawing—sketches, tracing.. *d* Topography........ } Drawing 1-2	84	Elements of the dynamo (E. E. 2)	56	Direct current laboratory (E. E. 72)	52	*The steam engine and boiler (M. E. 13-14)	65
Descriptive geometry (Draw. 3-4)	84	General geology (Geol. 103-104)	......	Economic geology (Geol. 105-106)	88	*Motors other than steam (M. E. 24)	......
General advanced physics (Phys. 4)	91	Differential and integral calculus (Math. 5-6)	91	Petrography (Geol. 4)	88	Heat and its applications (M. E. 71)	70
Gymnasium (Phys. Ed. A)	......	Analytical mechanics (Mech. 102)	91	Analytical mechanics (Mech. 101)	91	*Thermodynamics (Mech. 7)	91
Theory of plane surveying (C. E. 1-2)	46	Physical laboratory (Phys. 43)	91	Engineering of power plants (M. E. 69)	70	Metallurgy of lead, silver, gold, zinc, etc. (Met. 3)	39
Summer work:		Descriptive geometry (Draw. 3-4)	84	Experimental mechanical engineering (M. E. 76)	70	*Metallurgical laboratory (Met. 71-72)	41
Surveying Practice (C. E. 15)	47	Structural drawing (Draw. 7-8)	84	Metallurgy of copper (Met. 1)	39	Mine surveying (Mining 55)	35
		Gymnasium (Phys. Ed. B)	......	General metallurgy (Met. 2*a*)	39	Mine engineering (Mining 56)	33
		Descriptive and determinative mineralogy (Mining 1-2)	90	Metallurgy of iron and steel (Met. 2*b*)	39	Mine plant (Mining 71-72)	34
		Summer work:		Optical mineralogy (Mining 6)	90	Design of mine plant (Mining 75)	34
		Surveying Practice (C. E. 27)	47	Excavation and tunneling (Mining 51)	32	Graduating thesis or project (Mining 77-78)	35
		Railroad Surveying (C. E. 28)	48	Boring and shaft-sinking (Mining 52)	32	*Mill constructions (Mining 80)	35
				Prospecting, exploration, etc. (Mining 54)	32	Ore dressing (Mining 81-82)	33
				Mine constructions (Mining 70)	34	Ore dressing laboratory (Mining 82*a*)	33
						Administration (Mining 91-92)	35
						Mining law (Mining 94)	35
						Mining practice (Mining 95)	35

The First Class is identical for all courses.

* Mining option.
† Geological option.

COURSES IN METALLURGY

Undergraduate Courses

1—Metallurgy of Copper—The properties of copper and its alloys; the principles of roasting; the reverberatory and cupola smelting processes for oxide and for sulphide ores; the converter or Bessemerizing process. Text-book: Peters' *Modern Copper Smelting.* 2 hours lecture, third year. Dr. Kern

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of students in the Schools of Mines and Chemistry

2a—Electro-Metallurgy and Fuels—Electro-metallurgy, calorimetry, fuels (natural and artificial), refractory materials. 2 hours lecture during February and March, third year. Professor Stoughton and Dr. Kern

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of students in the Schools of Mines and Chemistry

2b—Metallurgy of Iron and Steel—The properties of steel, cast iron and wrought iron, as influenced by composition and by thermal and mechanical treatment, together with a brief account of the chief processes by which they are made. Text-book: Howe's *Iron, Steel and Other Alloys.* 2 hours lecture during April and May, third year. Professor Stoughton

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of students in Mining Engineering

3—Metallurgy of Lead, Silver, Gold, Zinc and the Minor Metals—Properties, alloys, ores, methods of extraction, separation and refining. Text-book: Hofman's *Metallurgy of Lead, etc.,* Collins' *Metallurgy of Silver,* Rose's *Metallurgy of Gold,* Ingalls' *Metallurgy of Zinc, etc.,* Reference, Schnabel's (Louis) *Handbook of Metallurgy.* 3 hours lecture, fourth year. Professor Campbell

Pre-requisite: Metallurgy 1, 2a and 62, for students in the School of Mines

Required of students in the Schools of Mines and Chemistry

4—Metallurgy of Iron and Steel—The blast furnace, puddling, Bessemer, open hearth and crucible processes. Rolling and forging metals. The properties of iron and steel as influenced by composition (including alloy steels), by mechanical and thermal treatment. The microscopic constitution of iron and steel. Text-book: Howe's *Iron, Steel and Other Alloys.* 2 hours, second year. Professor Stoughton

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of fourth year students in Chemistry and of second year students in Metallurgical, Civil, Electrical, Mechanical Engineering

51—Metallurgy of Copper—Extension of Metallurgy 1. 1 hour lecture or conference, third year. Dr. Kern

Pre-requisite or parallel: Metallurgy 1
Required of students in Metallurgical Engineering

52—Electro-Metallurgy and Fuels—Extension of Metallurgy 2a. The theory and application of electricity to the smelting of ores, and the extraction and refining of copper, lead, iron, zinc, aluminium, nickel, antimony, tin, bismuth, silver, gold and platinum. Fuels, with especial reference to recent progress. 1 hour conference, third year. Dr. Kern and assistant

Pre-requisite or parallel: Metallurgy 2a
Required of students in Metallurgical Engineering

53—Metallurgy of Lead, Silver, Gold, Zinc, etc.—Extension of Metallurgy 3. 1 hour lecture or conference, fourth year. Professor Campbell

Pre-requisite or parallel: Metallurgy 3
Required of students in Metallurgical Engineering

54—Metallurgy of Iron and Steel—Extension of Metallurgy 4. 2 hours lecture or conference, second year. Professor Stoughton

Pre-requisite or parallel: Metallurgy 4
Required of students in Metallurgical Engineering

56—Constitution and Properties of Alloys—Text-book: Howe's *Iron, Steel and Other Alloys.* 3 hours lecture or conference and one afternoon laboratory, during April and May, third year. Professor Campbell

Pre-requisite: Metallurgy 1 and 2a. Pre-requisite or parallel: Metallurgy 2b or 4
Required of students in Metallurgical Engineering

58—Metallography of Iron, Steel and Industrial Alloys—Constitution of iron, steel, brasses, bearing-metals, etc.; comparison of good with faulty material; cause and effect of defects; heat treatment, etc. Total of three lectures and three or more afternoons laboratory, second year. Professor Campbell

Pre-requisite or parallel: Metallurgy 2b or 4

62—Summer Course in Non-Ferrous Metallurgy—For description see page 34. Summer after third year. Professor Campbell and Dr. Kern

Pre-requisite: 1, 2a and 2b (or 4)
Required of students in the School of Mines

64—Summer Course in Ferrous Metallurgy—For description see page 34. Summer after second year. Professor Stoughton and assistant.

Pre-requisite **2b** or 4

Required of students in Metallurgical Engineering

71-72—Metallurgical Laboratory—Pyrometry; microscopic metallography; thermal treatment of steel; roasting; desilverizing base bullion. Text-book: Howe's *Metallurgical Laboratory Notes.* Total of 10 afternoons, fourth year. Professor Campbell, Dr. Kern and assistant

Pre-requisite: 1, **2a**, **2b** (or 4) and 3 (or parallel)

Required of students in Mining Engineering

77-78—Thesis

Pre-requisite 1, **2a**, **2b** (or 4), 3 (*or parallel*), 171-172 and 176

Required of students in Metallurgical Engineering

171-172—Metallurgical Laboratory—Pyrometry; calorific power of fuels; microscopic study of metals and alloys; thermal and mechanical treatment of steel and cast iron; roasting and smelting of ores; refining black copper; desilverizing base bullion; cupelling, roasting, lixiviating, cyanide, chlorination and electro-metallurgical processes; fusibility and other properties of slags and of refractory materials (see page 10, *Metallurgical Laboratory Notes*). Text-book: Howe's *Metallurgical Laboratory Notes.* 2 afternoons, third year. Professor Campbell, Dr. Kern and assistant

Pre-requisite, 1, **2a**, **2b** (or 4), 3 (or parallel)

Required of students in Metallurgical Engineering

176—The Art of Metallurgical Investigation—A total of ten afternoons' conferences. Professor Stoughton

Pre-requisite: 1, **2a**, **2b** (or 4) and 3 (or parallel)

Required of students in metallurgical engineering and graduate students carrying on investigations.

Graduate Courses

Special courses, consisting of original research, will be arranged for advanced students according to their individual needs and abilities. Most of these researches will consist of work in the departmental laboratories, but others will consist of study, and still others of work in industrial establishments.

The amount of time required for these courses is governed by the rule that a course or courses should occupy 18 hours a week (preparation included) if taken as a major subject, and 9 hours a week if taken as a minor subject for a degree of A.M., or half minor for a degree of

Ph.D. The following list shows what kinds of subjects are suited to these courses:

201-202 (*a*)—Advanced work on some problem in general metallurgy, as for example:

In Calorimetry: Determination of the calorific power of fuels, or testing some law in calorimetry;

In Pyrometry: Determination of the temperatures of metallurgical and other industrial high-temperature operations;

On Refractory Materials; their resistance to heat and corrosion; their tendency to slack; their contraction and expansion, etc.;

In Electro-metallurgy: Testing electro-metallurgical principles and refining, extraction and depositing process;

On Slags: The formation points, melting points, flowing points, and their density and viscosity when molten;

(*b*)—In the Metallurgy of Copper:

The chemistry of roasting processes, and especially the elimination of arsenic and sulphur;

The reactions of smelting processes;

Wet methods of extraction;

(*c*)—In the Metallurgy of Lead, Silver, Gold, etc.:

The lime-roasting of galena, and others mentioned above under (*b*);

(*d*)—In the Metallurgy of Iron and Steel:

The chemistry of the blast furnace;

The chemistry of the basic dephosphorizing processes;

The heat treatment of iron and steel: its physical, crystallographic and chemical effect;

The components and constitution of iron, steel, and alloy steels;

(*e*)—On Alloys: The constitution and properties of alloys, embracing a microscopic, pyrometric and mechanical or physical examination with a correlation of the results;

(*f*)—In Metallography: Metallography of iron, steel, industrial alloys or metallurgical products as mattes, slags, etc.

Prerequisite for 201-202, Metallurgy 1, 2, 3, and 71-72, or equivalent.

PROGRAM OF STUDY IN THE COURSE OF METALLURGICAL ENGINEERING

First Class	Page No.	Second Class	Page No.	Third Class	Page No.	Fourth Class	Page No.
General inorganic chemistry (Chem. 3-4)	75	Industrial chemistry (Chem. 81-82)	80	Assaying (Chem. 69 or 170)	80	Physical chemistry (Chem. 121-122)	75
Qualitative analysis (Chem. 61-62)	77	Quantitative analysis (Chem. 66)	78	Metallurgy of copper (Met. 1)	39	Advanced inorganic chemistry (Chem. 167-168)	78
Spherical trigonometry (Math. 2)	91	Descriptive geometry (Draw. 3-4)	84	Electro-metallurgy and fuels (Met. 2*a*)	39	Metallurgy of lead, silver, gold, zinc, etc. (Met. 3)	39
Analytical geometry (Math. 3-4)	91	Structural drawing......... Draw. 7-8	84	Extension of Met. 1 (Met. 51)	40	Extension of Metallurgy 3 (Met. 53)	40
a Elements of mechanical drawing...... *b* Projections......... *c* Machine drawing—sketches, tracing.. *d* Topography......... Draw. 1-2	84	General physics (Phys. 3)	91	Extension of Met. 2*a* (Met. 52)	40	Heat and its applications (M. E. 71)	70
Theory of plane surveying (C. E. 1-2)	46	Physical laboratory (Physics 43)	91	Metallurgy of alloys (Met. 56)	40	Motors other than steam (M. E. 24)	......
Descriptive geometry (Draw. 3-4)	84	Analytical mechanics (Mech. 102)	91	Metallurgical laboratory (Met. 171-172)	41	The steam engine and boiler (M. E. 13-14)	65
General advanced physics (Phys. 4)	91	General geology (Geol. 103-104)	......	Properties of materials (C. E. 6)	47	Electro-chemistry (E. E. 107-108)	......
Gymnasium (Phys. Ed. A)	......	Metallurgy of iron and steel (Met. 4)	39	Engineering of power plants (M. E. 12)	65	Ore dressing (Mining 81-82)	33
Summer work: Surveying Practice (C. E. 15)	47	Extension of Metallurgy 4 (Met. 54)	40	Principles of electrical engineering (E. E. 68)	57	Ore dressing laboratory (Mining 82*a*)	33
		Differential and integral calculus (Math. 5-6)	91	Direct current laboratory (E. E. 72)	52	Mine administration (Mining 92)	35
		Gymnasium (Phys. Ed. B)	......	Prospecting, exploration, development, etc. (Mining 54)	32	Metallurgical thesis (Met. 77-78)	41
		Electrical engineering (E. E. 1, 2)	56	Mine construction (Mining 70)	34	Art of metallurgical investigation (Met. 176)	41
		Summer work: Surveying Practice (C. E. 27)	47	Analytical mechanics (Mech. 101)	91		
		Iron and steel works visits (Met. 64)	41	Thermodynamics (Mech. 106)	91		
		Descriptive and determinative mineralogy (Min. 1-2)	90	Resistance of materials (C. E. 53-54)	48		
				Testing of materials (C. E. 55-56)	......		
				Graphic statics (C. E. 64)	49		
				Economic geology (Geol. 105-106)	88		
				Summer work: non-ferrous works visits (Met. 62)	40		
				Geology field work (Geol. 112)	89		

The First Class is identical for all courses.

CIVIL ENGINEERING

List of Officers

William Hubert Burr, C.E. . . . . *Professor*
Earl Brink Lovell, C.E. . . . . *Professor*
Ira H. Woolson, E.M. . . . . *Adjunct Professor*
Adolph Black, C.E. . . . . *Adjunct Professor*
Myron Samuel Falk, C.E., Ph.D. . . . . *Lecturer*
Charles Edward Morrison, C.E., A.M. . . . . *Tutor*
J. S. Macgregor, M.Sc. . . . . *Assistant*
Francis S. Foote, Jr., E.M. . . . . *Assistant*

General Statement

The four-year course leading to the degree of Civil Engineer is designed to afford a thorough analytical training, as well as numerous and extended practical exercises in those matters which pertain to the profession of the civil engineer, both in regard to all classes of structures and public works and in connection with the various developments and applications of power by the use of steam, electric, water, and air motors. This course is also designed to be an educational preparation for those duties or functions of an executive character whose discharge in connection with the management of public or other works requires or is rendered more efficient through a thorough knowledge of civil engineering. The breadth and nature of this educational training adapts it no less efficiently to the purposes of those who intend to follow callings not of an engineering character but which may be related more or less to manufacturing, to structural matters, or to the development and application of power. The theoretical portion of the instruction is based largely upon the courses given in the departments of Mathematics, Mechanics, and Physics, and the results obtained are applied to practical engineering work. Special stress is laid upon the design by the student of the various structures and machines which the civil engineer is called upon to construct in the practice of his profession. The instruction is given by lectures, demonstrations by the student, and frequent conferences, co-ordinate with which the work of design is continuously carried on. It covers comprehensively the subjects of surveying, road and railroad engineering, water supplies of cities and towns, irrigation, sanitary engineering, including sewage disposal; both graphic and analytic treatment of all metallic structures, foundations, retaining and reservoir walls, high masonry dams, sewer systems, hydraulic engineering, rivers and harbors, pumping engines, hydraulic, steam, and electric motors.

Ample facilities are afforded for post-graduate students in civil engineering, and special students are admitted to various engineering courses of the department upon evidence of proper qualifications.

Equipment

The school possesses an unusually full equipment of engineers' and solar transits, levels, plane tables, compasses, and all accessories, as well as smaller instruments. Current meters, hook gauges, and floats of various types are also used in making observations on the flow in and discharge of rivers and canals. A complete set of sections of iron and steel shapes, models and photographs of engineering works, together with working plans of the latter, are in the department for the use of students. The hydraulic laboratory affords opportunity for the practical operations of measuring the discharge through weirs and other orifices, the flow through open channels and closed pipes, frictional and other resistances in pipes and open channels, as well as for meter gaugings, and for general hydraulic investigations. The testing work in the mechanical laboratory includes the complete tests of various structural materials in tension, compression, bending, and torsion, including the observation and digesting of all corresponding data.

A cement-testing laboratory is fully equipped with testing machines, briquette molds, tanks, and other apparatus requisite for all classes of investigations in the nature and physical properties of cements and cement mortars.

A complete laboratory for the testing of road materials has been established and is constantly in use for investigations connected with materials suitable for road building. The facilities offered by the laboratory are full and sufficient to make all tests required to determine resistance to abrasion, classification of sand, gravel and broken stone and the cementing power of all qualities of road materials. The laboratory is at the service of students and is used by them, both for the ordinary prosecution of studies to which the determination of results is related and for the purposes of thesis work, and other similar investigations.

The Materials Testing Laboratory is located at the north end of the main floor of the Engineering Building. It is fully equipped with modern appliances for the conduct of tests upon all structural materials. There are seven testing machines varying in capacity from 600 lbs. to 400,000 lbs., representing all American types, including a 150,000-lb. Emery hydraulic power machine, which is a standard of accuracy, and the refinement of mechanical construction. These machines are suited to make tension, compression, transverse and torsion tests upon metal work, also to make all desired tests upon building materials such as timber, stone, brick, concrete blocks or concrete-steel beams, columns, partition blocks, and all built up materials.

The laboratory is also liberally supplied with a large assortment of extensometers, deflectometers, micrometers, gauges, and similar instruments of precision for measurement of test pieces.

Other apparatus such as delicate scales of different sizes for use in absorption and freezing tests on building materials, also pyrometers and furnaces for the conduct of fire tests upon all kinds of fire-resisting materials are available. Near the University is established the commodious Columbia Fire Testing Station. This is under control of the officers of the testing laboratory, and is equipped with several large test buildings and all necessary apparatus and appliances for making regulation fire, load and water tests upon walls, floors, partitions, etc., in full size units, as prescribed by the building codes of New York and Philadelphia. Commercial work of this character, as well as in the laboratory, is continually in progress, and is open to student observation at all times, thus keeping them in touch with the practical demands of the hour in this line of investigative work.

Summer Courses in Surveying

These courses are conducted during sixteen weeks of each summer vacation at a point in the country near Litchfield, Conn., where ample facilities are provided for all requisite operations, and where the topography is admirably adapted to the practical work of surveying. The operations at the summer course include the entire actual surveying of the department of Civil Engineering together with such lectures, computations, and mapping as can be given better in connection with the field-work than in the class-room. About six weeks' continuous attendance is required of each class between the first and second years, seven weeks between the second and third years, and four weeks between the third and fourth years. The equipment of engineers, and solar transits, levels, plane tables, compasses, and all accessories and smaller instruments is unusually complete. A corps of special assistants for each section aid the regular officers of instruction. At each session the following courses are given under the numbers: 15, 25, 26, 27, 71. The university issues a special pamphlet with regard to these courses, which may be had upon application to the Registrar.

COURSES IN CIVIL ENGINEERING

1-2—Theory of Surveying—for students in Mining Engineering—Pacing survey, contouring and levelling by hand-level—Construction, use, and adjustment of instruments—Farm survey—Theory of stadia measurements—Azimuth traverse—Repetition traverse—Polaris observations—Balancing survey. Text-book: Raymond's *Plane Surveying.*

Reference book: Johnson's *Theory of Surveying*. 1 hour. Professor LOVELL and Mr. FOOTE. Prereq.[1] Entrance Mathematics.

4. THEORY OF SURVEYING—for students in Civil Engineering. Same as 1-2. 2 hours. Prof. LOVELL and Mr. FOOTE. Prereq. Entrance Mathematics.

6—PROPERTIES OF MATERIALS—Sources of timber supply, varieties available, kinds adapted for different classes of constructive work; inspection, determination of variety from practical study of planks, logs, and trees; causes of decay and processes of preservation; fireproofing, etc. 2 hours. Professor WOOLSON.

7-8—TESTING OF MATERIALS—Discussion of properties of constructive materials, as shown by results of testing, by tension, compression, transverse, abrasion, and the like; rustless coatings and various methods of protecting metal work; bearing metal alloys, properties, composition, and testing. Fire-resisting materials employed in buildings; discussion of methods of application and efficiency. 2 hours. Professor WOOLSON. Prereq. 6.

15—SURVEYING BETWEEN THE FIRST AND SECOND YEARS—Pacing, chaining, and ranging—Farm survey—Adjustment of instruments—Angle reading by repetition—Repetition traverse—Azimuth traverse. Daily lectures, field and office work. Professor LOVELL, Mr. FOOTE and Assistants. Prereq. 1-2, or 4.

21—ROAD ENGINEERING—Surveys and location of highways—Drainage and grades—Foundations—Selection and treatment of materials—Telford and McAdam pavements—City pavements of brick, Belgian and granite blocks, asphalt, cement, and concrete—Machinery and tools required in the construction of roads and pavements—Maintenance of roads and pavements—Elements of expense and total cost of construction and maintenance—Reference book: Baker's *Roads and Pavements.* Lectures and recitations 2 hours. Mr. MORRISON.

23—An abridged course, for students in Mining Engineering, covering the same subjects as are taken in Course 51-52. 2 hours and 1 afternoon problem work. Professor LOVELL and assistant. Prereq. 15.

25—SURVEYING BETWEEN THE SECOND AND THIRD YEARS—for Civil Engineers—Levelling—Topographical survey with plane table—City surveys—Transit and Stadia—Use of solar attachment. Daily lectures, field and office work. Professor LOVELL, Mr. FOOTE and Assistants. Prereq. 15.

26—HYDROGRAPHIC SURVEYING—Triangulation—Topography on shore—Soundings—Current meter work—Computation of river or tidal discharge—Preparation of map. Professor LOVELL, Mr. FOOTE and Assistants. Prereq. 25.

27—SURVEYING BETWEEN THE SECOND AND THIRD YEARS—for stu-

[1] Hereafter, unless otherwise indicated, numbers given for prerequisites refer to courses in the same department.

dents in Mining Engineering. Same as 25, except city surveys, with mining claim. Prereq. 15.

28—Surveying between the Third and Fourth Years—for students in Mining Engineering—Railroad surveying—Reconnaissance—Preliminary survey—Location—Cross-sectioning—Computation — Economic comparisons from construction and operating standpoints—A complete survey and location of a line two to five miles long are made, with all the attendant computations requisite for placing the work under contract. Daily lectures, field and office work. Professor Lovell, Mr. Foote and Assistants. Prereq. 23, 27.

51-52—Theory of Railroad Surveying—Simple, compound, and reversed curves—Transition curves—Switch work—Cross-section work—Earthwork computations—Office work. Lectures and practical problems. 3 hours, with one afternoon problem work. Reference books: Searle's *Field Engineering* and Crandall's *Transition Curve and Earthwork.* Professor Lovell, Mr. Foote and Assistant. Prereq. 15.

53-54—Elasticity and Resistance of the Materials of Engineering—Laws of elasticity in homogeneous materials—Coefficients of elasticity—Relations between stresses and strains—Common and exact theories of torsion and flexure—Elastic limits, working stresses, and ultimate resistances of wrought iron, cast iron, steel, alloys, timbers, building-stones, cement, concrete, and masonry—Reinforced concrete construction—Complete treatment of simple and continuous beams—The design and construction of iron, steel, and timber columns and beams, including the design and construction of plate girders —Shafts—Cables—Fatigue of materials—Specifications. 3 hours lectures and recitations first half, and 2 hours second half year. 4 hours first half-year, and 5 hours second half-year, of problem and design work. Reference and text-book: Burr's *Elasticity and Resistance of Materials.* Professor Burr, and Mr. Morrison. Prereq. Mechanics 101-102.

58—Masonry Structures—Pressure and abutting power of earth —Design and construction of retaining walls—Stability of masonry structures in general—Stability of towers and chimneys under wind pressure—Theory and design of arches with vertical and inclined loads—Theory and design of reservoir walls, earth and high masonry dams—Theory and design of masonry domes—Cement, concrete, and masonry. Reference books: Cain's *Retaining Walls* and Baker's *Masonry and Foundations.* Lectures 3 hours with frequent conferences and continuous work in design. Cement and mortar testing in the cement-testing laboratory are required of all students. Mr. Morrison. Prereq. Mechanics 101-102, Mineralogy 5.

59—Sanitary Treatment of Water-Supplies and of Sewage—Treatment and disposal of sewage and refuse of manufacturing—Sedimentation by gravity and by chemical precipitation—Treatment of

effluent by continuous and intermittent sand filtration—Septic tanks—Contact beds—Percolating or trickling filters—Fertilization—Intermittent application to soil with under-drainage—Disposal of sludge—Plant for sewage treatment—Theory and construction of sand filters—Pollution of potable water and its purification by continuous and intermittent sand filtration—Mechanical filtration—Copper sulphate, ozone and other treatments for special waters—Design of sand filter for water purification. 2 hours lectures. Examinations of and reports on typical purification works. Text-books: *Filtration of Public Water Supplies,* Hazen; *Purification of Sewage,* Barwise. Prof. Black. Prereq. Chemistry 81-82.

61—Analytical Theory of Trusses—The truss element—Simple cantilever and non-continuous trusses with parallel chords—Fixed and moving loads—Through and deck spans—Positions of any system of concentrated moving loads for greatest chord and web stresses when chords are both parallel and not parallel—Combination of moments and graphic methods—Skew and irregular trusses—Applications to bridge and roof trusses—Braced arches and arched ribs. 2 hours lectures, with frequent conferences and problems in computations of stresses and preparation of stress sheets. 1 afternoon of problem and design work in the drawing academy. Reference and text-book: Burr and Falk's *Metallic Bridges.* Mr. Morrison. Prereq. Mechanics 101-102

62—Graphic Statics—for students in Civil Engineering—Equilibrium polygon, and polygonal frames for all systems of loads—Graphical representations of shears and moments for both non-continuous and continuous beams—Fixed and moving loads—Lines of influence—Applications to bridge and roof trusses. 2 hours lectures. 1 afternoon of problem and design work in the drawing academy. Reference and text-book: Burr and Falk's *Influence Lines.* Mr. Morrison. Prereq. Mechanics 101-102.

64—Graphic Statics—An abridged course, covering the subjects taken in Course 62. 1 hour and one afternoon, for mining engineers and metallurgist. Mr. Morrison. Prereq. Mechanics 101-102.

71—Surveying between the Third and Fourth Years—for students in Civil Engineering—Railroad Surveying—Reconnaissance—Preliminary survey — Location — Cross-sectioning — Computations—Economic comparisons from construction and operation standpoints—A complete survey and location of a line two to five miles long are made, with all the attendant computations requisite for placing the work under contract. Daily lectures, field and office work. Professor Lovell and Assistants. Prereq. 51-52 and 25.

75—Hydraulics—Flow of water through orifices—Time required for discharge of canal locks and similar volumes—Weir discharge and gauging by weirs—Gauging of water for systems of irrigation—Flow

through and discharge of pipes—Design of pipe systems for city waterworks—The Venturi meter—Flow in and discharge of open canals and rivers—Gauging of streams by current meters, floats and other means—Backwater. 3 hours lectures, with 1 afternoon laboratory work, conferences and problems. Text-book: Merriman's *Hydraulics.* Prof. Black. Prereq. Mechanics 101-102.

76—Hydraulics—for students in Mining Engineering—Same as 75. 3 hours during March, April and May. Prof. Black and Mr. Morrison. Prereq. Mechanics 101-102.

77—Hydraulics—for students in Electrical Engineering—Similar to course 75, but shorter. In addition it deals with the general considerations of rainfall, evaporation, percolation, run-off, net yield and storage; conduction of water from source to power-house, hydraulic losses and effective head on wheel; estimation of power. 2 hours lectures. Text-book: Merriman's *Hydraulics.* Reference book: Turneaure and Russell's *Public Water Supplies.* Prof. Black.

78—Hydraulics—for students in Mechanical Engineering—Same as 76. 2 hours a week. Prof. Black.

85—Foundations—Earth foundations—Foundations for buildings—Safe loads on masonry and foundation beds—Pile driving and pile foundations—Safe loads for piles—Protection and preservation of piles and timber—Sheet piling and coffer-dam methods—Pneumatic foundations and caisson work—Open dredging—Bridge piers of masonry and cylinders—Piers for deep foundations—Methods of working in quicksands—Tunneling. Reference books: Patton's *Foundations* and Baker's *Masonry and Foundations.* 2 hours lectures, with frequent conferences and continuous work in design. 1 afternoon of problem and design work in the drawing academy. Professor Burr. Prereq. 57-58, Geology 18.

87-88—The Design and Construction of Bridges, Roofs, and Buildings—Railway and highway bridges—Pin and riveted connections—Single and multiple system of bracing—The design of details for bridges, roofs, and buildings—Floors for railway and highway bridges—The design and operation of draw-bridges, including engines, locking, lifting, and turning machinery—Cantilever structures—Wind loads and stresses—Single and double-track viaducts or trestles in iron, steel, and timber—Lateral and transverse systems of bracing—The design and construction of elevated railroads—The complete designs of railway structures, with estimates of cost—The erection of iron, steel, and timber structures, including the cost of erection. 2 hours lectures and recitations, with frequent conferences and continuous work in design. 1 afternoon of problem and design work in the drawing academy. First half-year only for sanitary engineers. Reference and text books: Burr and Falk's *Influence Lines;* Burr and Falk's *Metallic Bridges.* Prof. Burr, Mr. Morrison and Dr. Falk. Prereq. 53-54, 61-62.

89-90—Railroad Engineering—Construction and operation—Train resistance, sources and probable value—Curvature and grades, their relation to velocity and maximum train-load—Effect of momentum—Reduction of grades at starting points—Balance of grades for unequal traffic—Study of annual reports—Analysis of operating expenses—Cost of operating, including maintenance, per train mile—Itemized statements of costs and percentage to total cost—Cost of extra distance, curvature, rise and fall, or of additional trains—Effect of roadbed on cost of running trains—Justifiable expenditure in construction to save one mile of distance, one degree of curvature, one foot of rise and fall, or to reduce ruling grade .1% per daily train per year—Pusher grade for one or more assistant engines—Economical use of pusher grades—Cost of excessive or limiting curvature—Value of additional traffic—Principles to follow in locating new lines—General policy of improvements in old lines—Principles in design and construction of railroad yards and terminals—Computations and detail drawings of turnouts, slip switches and ladder tracks—Development and present practice in block signalling and interlocking, with problems in design and estimates of cost of installation—Classification and cost of earthwork—Graduation, cross section in excavation and embankment, and protection of slopes—Ordinary and extraordinary methods of drainage—Water supply, its quality, storage, and delivery—Principles of construction of wooden trestles and masonry culverts, including preparation of standard plans and estimates of cost—Ballast—Track, track accessories and maintenance of way details—Organization—Management. 3 lectures. 5 hours of problem and design work in the drawing academy. Reference books: Wellington's *Railway Location—The Block System*, Adams—Tratman's *Track and Track Work*—Dewsnap's *Railway Organization and Working*. Professor Lovell. Prereq. 71.

94—The Design and Construction of Sewers, and Irrigation—Sewerage and surface drainage of cities and towns—Separate and combined systems of sewers—Capacities of mains and branches—Catch basins—Manholes—Chimneys or ventilators—Flush tanks—Outfalls—Grades—Flow or discharge of sewers—Construction. Irrigation of land—Amounts and periods of application—Construction of, and flow through, diversion and distributing canals. Text and reference books: *Separate System of Sewerage,* Staley and Pierson—*Sewer Design,* Ogden—*Irrigation Engineering,* Wilson. 2 hours lectures, recitations, problem and design work. Prof. Black. Prereq. 26, 59, 75.

98—Water-Supply Engineering and River and Harbor Improvements—Rainfall and storage—Flow of streams—Influence of soils, elevation, geological character of water-shed—Methods of supply, gravitation, pumping from rivers or natural underground storage, flow from the latter—Reservoir construction—Distributing system. House supply and wastage. River and Harbor Improvements—Jetty sys-

tem of river improvements—Scouring action of currents—Erosion of river banks—Dams for improvement of river navigation—Breakwaters—Dykes—Groins—Mattress work—Docks—Harbor works—Iron piers—Estimates of cost. Text-book: *Public Water Supplies,* Turneaure & Russell. 2 hours lectures, recitations, problem and design work. Prof. BLACK. Prereq. 26, 59, 75.

100—Graduation Thesis—A project or thesis on some civil engineering subject, approved by the head of the department, is required of every candidate for the degree of Civil Engineer.

Courses in Sanitary Engineering

41—SANITARY ENGINEERING OF BUILDINGS—Water-pipe systems—Treatment and disposition of all refuse and waste products—Trapping and ventilation of basins, closets, and sewer pipes—Drainage of buildings and building sites—Plumbing of buildings. 2 hours. Prof. BLACK

42—GENERAL PRINCIPLES OF HYGIENE AND SANITARY SCIENCE—Effects of water supply on public health—Metallic pipes for water—Effects of impure air on health—Influence of conditions of soils on health—Remedial measures applicable to unsanitary conditions—Sewage air—Disposition of sewage—Sanitary treatment of buildings—Contagious and other diseases. 2 hours. Prof. BLACK

81-82—HEATING AND VENTILATION—General features of systems of heating and of ventilation—Steam heating—Hot-water heating—Heating with hot air—Hot-water circulation—Plant required in different systems of heating—Amounts of fresh air required in buildings devoted to various purposes—Modes of introducing fresh air and withdrawing foul air—Power for and capacities of systems of artificial ventilation—Complete designs for heating and ventilating plants. 2 hours.

84—DRAINAGE OF COUNTRY DISTRICTS AND TOWNS—Requisite surveys—Effects of topography and character of materials—Surface and subsurface waters—Disposal of drainage waters—Designs for drainage systems. 2 hours. Prof. BLACK

Advanced Courses

The minor subjects in the department of Civil Engineering for the University degrees of Master of Arts and Doctor of Philosophy (those courses which fulfill the residence requirements) are the following:

153-154—ELASTICITY AND RESISTANCE OF MINERALS.

257-258—ELASTIC AND MASONRY ARCHES—Open to those who have taken 57-58. Conferences, reading and design work, as required.

275-276—HYDRAULICS (75 with additional reading).

285-286—FOUNDATIONS, including theory of earth pressure (85 with additional reading).

287-288—Long Span Bridges—Open to those who have taken Civil Engineering 87-88. Conferences, with reading and design work as required.

The major subjects for the same University degrees are the following:

259-260—Sanitary Engineering, prerequisites: courses 59, 94, 98.

277-278—Hydraulic Engineering, including the hydraulics of rivers and power plants and municipal water-works.

279-280—Municipal Engineering, including water-works, sewers and sewage works, streets and other public works and their administration.

289-290—The Engineering of Structures, including long span bridges and deep foundations, with methods of building them, and advanced work in Elasticity and Resistance of materials.

PROGRAM OF STUDIES IN THE COURSE OF CIVIL ENGINEERING

First Class	Page No.	Second Class	Page No.	Third Class	Page No.	Fourth Class	Page No.
General inorganic chemistry (Chem. 3-4)	75	Industrial chemistry (Chem. 81-82)	80	Geodesy (Ast. 105-106)	87	†Geodesy (Ast. 109)	87
Qualitative analysis (Chem. 61-62)	77	Road engineering (C. E. 21)	47	Theory of railroad location (C. E. 51-52)	48	Hydraulics (C. E. 75)	49
Spherical trigonometry (Math. 2)	91	*Elements of electrical engineering (E. E. 1)	56	Resistance of materials (C. E. 53-54)	48	Kinematics of machinery (M. E. 35)	69
Analytical geometry (Math. 3-4)	91	*Elements of the dynamo (E. E. 2)	56	Testing laboratory (C. E. 55-56)	......	Foundations (C. E. 85)	50
a Elements of mechanical drawing...... (Drawing 1–2)		General geology (Geol. 18)	88	Masonry structures (C. E. 57-58)	48	‡Design of bridges and buildings (C. E. 87-88)	50
Freehand lettering.. (Drawing 1–2)		Differential and integral calculus (Math. 5-6)	91	Water supply and sewage (C. E. 59)	48	Railroad engineering (C. E. 89-90)	51
b Projections......... (Drawing 1–2)	84	Graphics (Draw. 5-6)	84	Theory of trusses (C. E. 61)	49	Design and construction of sewers and irrigation (C. E. 94)	51
c Machine drawing—sketches, tracing.. (Drawing 1–2)		Structural drawing (Draw. 7-8)	84	Graphic statics (C. E. 62)	49	Water supply and river and harbor improvements (C. E. 98)	51
d Topography........ (Drawing 1–2)		Analytical mechanics (Mech. 102)	91	Principles of electrical engineering (E. E. 68)	57	Graduation thesis (C. E. 100)	52
Theory of surveying (C. E. 2)	46	Metallurgy of iron and steel (Met. 4)	39	Direct current laboratory (E. E. 72)	52	The steam engine and boiler (M. E. 13-14)	65
Descriptive geometry (Draw. 3-4)	84	Minerals of building stones (Mining 5)	90	Engineering of power plants (M. E. 12)	65	Motors other than steam (M. E. 24)	......
General physics (Phys. 3-4)	91	General Physics (Phys. 3)	91	Analytical mechanics (Mech. 101)	91	Heat and its applications (M. E. 71)	70
Gymnasium (Phys. Ed. A)	......	Physical laboratory (Phys. 43-44)	91	Thermodynamics (Mech. 106)	91	Experimental mechanical engineering (M. E. 76)	70
Practical surveying (C. E. 15)	47	Gymnasium (Phys. Ed. B)	......				
Summer work:		Summer work:		Summer work:			
Surveying practice	47	Surveying practice (C. E. 25)	47	Geodesy (Ast. 107)	87		
		Hydrographic surveying (C. E. 26)	47	Railroad surveying (C. E. 71)	49		

***Students in Sanitary Engineering do not take these courses, but must take instead Civil Engineering 14 and General Biology.**
†Students in Sanitary Engineering must offer in addition microscopy.
‡Students in Sanitary Engineering take only 87.
The First Class is identical in all courses.

ELECTRICAL ENGINEERING

List of Officers

Francis B. Crocker, E.M., Ph.D. . . . . *Professor*
George Francis Sever, M.Sc. . . . . *Professor*
Morton Arendt, E.E. . . . . *Instructor*
Edgar S. Downs, Ph.D. . . . . *Tutor*
Victor R. Greiff, E.E. . . . . *Assistant*

General Statement

The regular four-years' course leading to the degree of Electrical Engineer (E.E.) is designed for the education of professional electrical engineers who intend to devote their lives to the practice of this profession, either as engineers, managers, experts in manufacturing or other industrial enterprises, or as teachers in colleges and scientific schools.

The course of instruction includes not only all important branches of theoretical and applied electricity, but also the other collateral sciences which have been found by experience to be required by the electrical engineer, such as mathematics, physics, chemistry, drawing, analytical mechanics, mechanical engineering, including a thorough course in steam and other engines, as well as transmissive machinery and shop-work; general engineering, including construction in masonry, iron, steel, and wood, also forms part of the course.

Hence the graduate in the course in Electrical Engineering is provided not only with a thorough knowledge of the principles and practice of electricity, but also with such a broad and liberal education in the allied sciences as will prepare him for every demand that is likely to be made upon him in after life in connection with his profession, and will also enable him to become an investigator.

The instruction is by lecture, recitation, laboratory, work-shop, and drawing-room practice, with periodical examinations.

Special attention is given to new methods and forms of apparatus, in order that the student may be brought fully abreast of the rapid progress of electrical science and practice.

Frequent visits are made to the numerous electrical factories, stations, and other establishments in and about New York.

Equipment

The offices, laboratories, lecture and other rooms of the Electrical Engineering Department are in the south end of Engineering. In the basement are situated the two machine laboratories, containing the

direct-current machinery and the alternating-current apparatus. The smaller machines are mounted upon three long heavy tables, which brings them to a convenient height, and also affords space for instruments, note-books, etc.

The various dynamos include examples of 115 to 500 volt constant potential generators, constant-current arc-lighting dynamos, and other typical machines. Several types of stationary and railway motors, as well as motor dynamos, are also placed in the room. Machine and hand tools are provided for making and repairing apparatus, attachments, etc. Complete sets of ampère, volt and watt meters, speed indicators, transmission and absorption dynamometers, are available for testing the various generators and motors.

The alternating-current apparatus is placed in the other machinery laboratory, including single-phase and polyphase generators, induction and synchronous motors, and various types and sizes of transformers. Each alternator is driven by a separate electric motor, enabling its speed to be independently regulated. Complete sets of alternating current measuring instruments and wave-tracing apparatus are also provided.

On the first floor are situated the smaller lecture-room (seating 70), ordinarily used for class work, and the larger lecture-room (seating 150) for combined classes.

The museum contains cases for the collection of apparatus, models, materials, etc., relating to Electrical Engineering. This museum adjoins the lecture-rooms, so that its contents can be conveniently used for illustrating the lectures.

On the third floor are located the large instrumental laboratory, the drawing-room, and the studies of the officers. The laboratory contains tables on which the instruments are permanently set up ready for use. These include various forms of galvanometers, ampère balances, standard cells and resistances; apparatus for measuring inductance, magnetic permeability, hysteresis, and magnetic leakage; laboratory standard volt and ampère meters, potentiometer, a storage battery to supply steady currents for calibration purposes; apparatus for cable testing, etc.

COURSES IN ELECTRICAL ENGINEERING

1—Elements of Electrical Engineering—General electrical principles, laws, measurements, and the introduction to their applications. Text-book: Thompson's *Elementary Lessons in Electricity and Magnetism*. 2 hours. Mr. Prereq. Physics 3-4.

2—Elements of the Dynamo—Text-book: Crocker's *Electric Lighting*, Vol. I. 1 hour. Professor Crocker and Mr. Arendt. Prereq. Electrical Engineering 1.

51—Theory of the Dynamo—Predetermination and study of charac-

teristic curves of dynamos and motors. 1 hour. Mr. Prereq. 1, 2 and Mathematics 5-6.

52—DESIGN OF DIRECT-CURRENT MACHINERY—Complete and original design of a dynamo or motor with working drawings, tracings, blue prints, and all calculations. Text-book: Thompson's *Design of Dynamos.* 2 hours and 1 afternoon. Professor SEVER. Prereq. 1, 2, 101.

54—DESIGN OF ALTERNATING CURRENT MACHINERY—The principles, methods and data employed in the design of single-phase and polyphase alternating current generators, motors, transformers, rotary converters, transmission lines, etc., including the actual calculations and drawings for a piece of apparatus. 2 hours. Mr. Prereq. Mechanics 109 and as a parallel course, Electrical Engineering 175-176.

56—ELECTRICAL ENGINEERING—A study of the systems of direct current distribution. Direct current motors, and direct current lighting equipments, with problems. 2 hours. Professors CROCKER and SEVER.

68—ELECTRICAL ENGINEERING—The principles of Electrical Engineering and their application to general engineering. 1 hour lecture. Mr. ARENDT. Prerequisites: Physics 3-4. Electrical Engineering 1 and 2.

This course is not taken by students in Electrical Engineering, but by all third-year students in Civil, Sanitary, and Mining Engineering, Chemistry (Course B), and Metallurgy.

72—DIRECT CURRENT LABORATORY—Short course for students in Civil, Sanitary, and Mining Engineering, Metallurgy, Chemistry and Chemical Engineering. Text-book: Sever's *Electrical Engineering Experiments, etc.* 1 afternoon laboratory work. Professor SEVER and Assistants. Prerequisites: Physics 3-4 and Electrical Engineering 1 and 2.

1. Hereafter, unless otherwise indicated, numbers given for prerequisites refer to courses in the same department.

73—DIRECT CURRENT LABORATORY—Short course for students in Mechanical Engineering. Text-book: Sever's *Electrical Engineering Experiments and Tests on Direct Current Machinery.* 1 afternoon. Professor SEVER and Assistants. Prereq. 1 and 2. Parallel course, 101.

75—ALTERNATING CURRENT LABORATORY—Short course for students in Mechanical Engineering. Covers the important elementary phenomena of alternating currents. Townsend's *Laboratory Notes.* Mr. 1 afternoon laboratory work. Prereq. 73.

101—DYNAMO AND MOTOR PRACTICE—Principles, design and construction and testing of dynamos and electric motors. Text-books: Crocker's *Electric Lighting,* Vol. I.; Sever and Townsend's *Laboratory and Factory Tests.* 2 hours. Professor SEVER. Prereq. Electrical Engineering 2.

103—ELECTRIC POWER—Electric motors, their action, control and application. 2 hours. Professor CROCKER and Mr. ARENDT. Prereq. 101, 104.

104—Electrical Plants—The design, installation, and operation of electric lighting systems and plants, including a discussion of each of the various elements and methods employed. Text-book: Crocker's *Electric Lighting,* Vols. I and II. 2 hours. Professor Crocker and Mr. Arendt. Prereq. 1, 2, 101.

105—Electrical Distribution—Principles and methods of transmitting and distributing direct as well as alternating currents; series, parallel, and multiple wire systems; regulation of voltage and current; transformers; meters; arc and incandescent lamps. Text-book: Crocker's *Electric Lighting,* Vol. II. 2 hours. Professor Crocker and Mr. Arendt. Prereq. 101, 104.

106—Management of Electrical Plants—Economy in the design, construction, and operation of electrical stations, plants, and factories; organization, administration, accounts, specifications, contracts, laws, and insurance rules, accidents, patents and statistics in relation to electrical work. 2 hours. Professor Crocker and Mr. Arendt. Prereq. 103, 104, 105.

110—Telegraph and Telephone—The principal methods and instruments employed in telegraphy, telephony, and electric signalling. Text-books: Maver's *American Telegraph Practice;* Miller's *American Telephone Practice.* 2 hours. Professor Crocker and Mr. Arendt. Prerequisite: 1 and 2.

112—Electric Railway—Special instruction in design, installation, and operation of the various systems of electric railways. 2 hours. Professor Sever. 1, 2, 104.

173-174—Direct-Current Laboratory.

1. Practice in the accurate use of voltmeters and ammeters for the measurements of E. M. F.'s, currents and resistances.

2. Direct-current dynamos and motors.

(1) Measurement of the resistances of the various electrical circuits in a dynamo. Comparison of methods. Insulation tests. Determination of the heating limit under full-load conditions. Operation of various kinds of dynamos and motors. Investigation and measurement of Counter E. M. F., in a motor.

(2) Determination of the efficiency of dynamos and motors by the use of transmission dynamometers and friction brakes. Use of electrical methods for the determination of the efficiencies of motors, dynamos, and motor-dynamos. Comparison of methods. Operation of dynamos in parallel.

(3) Determination and plotting of the various characteristic curves of dynamos and motors, shunt, series, compound, and differential.

Text-book: Sever and Townsend's *Laboratory and Factory Tests in Electrical Engineering.* 2 afternoons. Professor Sever and Assistants. 1, 2. Parallel courses 101, 104.

175-176—Alternating Current Laboratory.

1. Practice in alternating current measurements with commercial instruments.

2. Introductory experiments on the general properties of alternating current circuits.

3. Determination, by various methods, of the efficiency of transformers. Determination of the values of the different losses.

4. Determination and plotting of curves of potential, current and power, etc., under different conditions.

5. Operation of alternating current dynamos and motors. Determination of their characteristic curves. Brake and efficiency tests.

6. Experiments with polyphase currents. Construction of vector diagrams from actual determinations. Determination and plotting of the several potential, current, and power curves. Alternators in parallel.

7. Transformation from one polyphase system into another by means of static transformers. Text-book: Sever and Townsend's *Laboratory and Factory Tests in Electrical Engineering.* 1 hour lecture and 2 afternoons. Mr. 104, 173-174. Parallel courses, Mechanics 109-110.

177—ELECTRICAL LABORATORY.

Calibration of commercial measuring instruments and advanced electrical measurements, including self-induction, capacity, and magnetic measurements, storage-battery and lamp testing, as follows:

1. By comparison with a Kelvin balance, the calibration of (*a*) an ammeter, (*b*) a Siemens dynamometer.

2. Calibration of a voltmeter.

3. Determination of the constant of a watt-hour meter.

4. Measurements of inductance and capacity. (*a*) Comparison of inductances. (*b*) Determination of a coefficient of self-induction. (*c*) Comparison of capacities. (*d*) Absolute determinations of a capacity and a self-induction.

5. Magnetic measurements. (*a*) Measurements relating to the magnetic leakage of a dynamo or motor. (*b*) Determination of the permeability of samples of iron and steel. (*c*) Measurement of hysteresis of samples of iron or steel by several methods.

6. Storage-battery testing, including determinations of the efficiency, output, and variation of potential at different rates of charge and discharge.

7. Photometry of electric lamps, including determinations of maximum and mean candle-power of the various forms of arc and incandescent lamps.

8. Adjustment and operation of telegraph, telephone and electrical signalling apparatus. 3 afternoons and 1 hour lecture. Text-book: Sever and Townsend's *Laboratory and Factory Tests in Electrical Engineering.* Mr. HOLCOMBE. Prereq. 173-174.

Graduate Courses

101, 104 and 173-174—Dynamo and Motor Practice, Electrical Plants and Electrical Laboratory—2 hours and 5 hours laboratory. Prerequisites: Courses 1 and 2.

103, 105, 106, 175-176 and 177—Electric Power, Electrical Distribution, Management of Electric Plants and Electrical Laboratory—3 hours, and 2 afternoons laboratory. Prereq. Physics 3-4 and Electrical Engineering 1, 4, and 10.

175-176—Alternating Current Laboratory—With Mechanics 109 and 110—3 hours first half-year, 2 hours second half-year, and 2 afternoons throughout the year. Prereq. Mechanics 108, 173-174.

201-202—Special Problems and Original Investigations in Advanced Electrical Engineering, with conferences and laboratory work as required. Prereq. All courses in the department.

PROGRAM OF STUDY IN THE COURSE OF ELECTRICAL ENGINEERING

First Class	Page No.	Second Class	Page No.	Third Class	Page No.	Fourth Class	Page No.
General inorganic chemistry (Chem. 3-4)	75	Quantitative analysis (Chem. 65)	78	Resistance of materials (C. E. 53-54)	48	Theoretical electro-chemistry (Chem. 37)	75
Qualitative analysis (Chem. 61-62)	77	Industrial chemistry (Chem. 81-82)	80	Testing laboratory (C. E. 55-56)	......	Industrial electro-chemistry (Chem. 183-184)	82
Drawing 1-2: *a* Elements of mechanical drawing...... Freehand lettering.. *b* Projections......... *o* Machine drawing-sketches, tracing.. *d* Topography........	84	Graphics (Draw. 5-6)	84	Theory of the dynamo (E. E. 51)	56	Hydraulics (C. E. 77)	50
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The First Class is identical in all courses.

MECHANICAL ENGINEERING

List of Officers

CHARLES E. LUCKE, M.S., Ph.D. .... *Adjunct Professor*
WALTER RAUTENSTRAUCH, M.S. .... *Adjunct Professor*
HARRY L. PARR, A.B., Mech.E. .... *Instructor*
EDWARD J. KUNZE, B.S., M.E. .... *Tutor*
EDWARD D. THURSTON, JR., A.B., Mech.E. .... *Assistant*

General Statement

The regular four-year course, leading to the degree of Mechanical Engineer, offers a thorough basic training in the design, construction, manufacture and operation of all classes of standard and special machinery, mills, shops, factories and power plants, as well as in the technical and executive management of the dependent industries. To this end the course of instruction is as broad as is consistent with the directness of its purpose. The Mechanical Engineer must not only be grounded in the fundamental scientific basis of his profession, and so trained as to be capable of applying this to both the technical and commercial aspects of industrial problems, but his immediate usefulness upon graduation demands that a considerable portion of the instruction be concerned with the practical application of the principles taught.

The course begins with a thorough training in mathematics, physics and chemistry as a foundation for the appropriate technical work, which is developed along several parallel lines. Applications of these fundamental sciences to the physical properties of the materials of construction, especially the metals and their practical manipulation, lead through the courses in metallurgy, mechanics, resistance of materials, shop work and the materials testing laboratory, drafting, kinematics to the principles of design, which are fixed by application to the design of special machinery for the execution of any specified manufacturing process and to certain standard machinery, such as steam and gas engines. The principles underlying the performance of machinery are developed by courses in thermodynamics, mechanics and hydraulics and the experimental laboratory. The instruction in the performance, design and manufacture of machines and power units in the class-room and laboratory, supplemented by frequent visits to power plants and factories, is the basis of the work on the design of plants and mills.

Throughout the instruction the student is thrown as much as possible on his own resources, encouraged to use such knowledge as he possesses, to read standard authorities and to make comparisons between

the existing data on various subjects and with the results of theoretical computations. In the experimental work special stress is laid upon this as a means for the development of that initiative, executive ability and spirit of investigation so necessary for the successful practice of the profession, which is one long series of new problems demanding solution. The graduating thesis, which is intended to be a culmination of this phase of the work, consists in the execution of a project of professional grade, the instructors assisting only in an advisory capacity. The commercial and industrial phases of the technical subjects are dwelt upon throughout the entire course of instruction, and particular attention is given to labor and cost systems, works management, economy of manufacture and power generation.

The overlapping of the Mechanical Engineering and Electrical Engineering professions makes it desirable that the Mechanical Engineer shall be thoroughly conversant with the ordinary problems of the Electrical Engineer in the generation and distribution of electric current, the characteristics of electrical machinery, its manufacture, and the design and installation of electrical plants. To this end students in this course receive instruction in the department of Electrical Engineering covering these subjects.

Graduate work in Mechanical Engineering is offered to students who have successfully completed the undergraduate course. This graduate work includes the more difficult applications of mechanics and thermodynamics to questions of engineering, as well as special investigations in design, experimental research, and the development of new processes of manufacture. Special students are admitted to any of the courses upon evidence of proper qualifications. Courses are also offered to students in other departments covering such instruction in Mechanical Engineering as may properly assist in the practice of their respective professions.

Equipment

Besides the usual offices, lecture rooms, drawing rooms and museum, the department is unusually well equipped with experimental laboratory facilities. These laboratories cover a floor space of some 12,000 sq. ft. and contain apparatus valued roughly at $75.000. A fairly full line of instruments for making simple measurements is always available for regular student work, and includes thermometers, pyrometers, barometers, simple and differential manometers, draft gauges, speed counters, tachometers, angular velocity meters, such as the Sargent and Ransom, planimeters, Pitot tubes, water meters, piston and Venturi type, hook gauges, gas meters, steam calorimeters, gas calorimeters, coal and oil calorimeters, flue gas analysis apparatus, scales for weighing and measuring, transmission dynamos, Prony brakes, indicators of all types, pressure and vacuum gauges, ammeters, mercury columns, calibrating apparatus for all instruments. Besides these measuring devices there

is a large number of pieces of special apparatus for various purposes, such as the testing of carburetors, pressures due to explosion of gas mixtures, rate of propagation of explosive mixtures, pressure and temperatures of vaporization of liquid fuels, loss of head in steam, air and water pipes, condensation of steam in pipes, bare and covered, flow of steam or water through orifices and turbine nozzles, capacity of steam traps, flash, chill, density, viscosity and carbonization of oils, friction of bearings, losses in power transmission. These various instruments and pieces of special apparatus are grouped and used in connection with a considerable number of machines of standard form. These include a standard gauge Vauclain compound locomotive, rated at 1600 I.H.P., mounted on friction wheels equipped with dynamometers. This locomotive is so erected that it can be operated with its own steam, line steam or compressed air, the exhaust passing through an induced draft fan separately driven by a small steam engine. A Reynolds Allis-Corliss triple expansion engine of 150 H.P., double eccentric type, is equipped to operate condensing and non-condensing, and is fitted with reheating receivers and may be operated with line steam or high pressure steam from the locomotive boiler. This Corliss engine has a tandem connection to three air cylinders, equipped with Gutermuth flap valves, operating three-stage with water intercoolers. A cross compound steam two-stage air compressor of the Ingersoll-Sargent type operates in parallel with the other air compressor and a Westinghouse simple air pump with complete air brake equipment. There is also a belt driven fan for fan investigations. Besides the steam engines mentioned there are also a Westinghouse two-cylinder, single-acting; McIntosh and Seymour automatic; Sweet straight-line simple engine, besides some smaller reciprocating units, and a De Laval steam turbine, all piped to condensers for efficiency tests. A Foster superheater separately fired in connection with three surface condensers, Wheeler, Worthington, Allis, each with its own air and circulating pumps, adds considerably to the steam equipment, which includes also typical injectors, steam traps, feed water heaters, steam separators, reducing valves, safety valves, back pressure valves and other ordinary steam auxiliaries and specialties. The hydraulic work is well provided for by two large 20,000-lb. measuring tanks, fitted with swinging guide-bucket for continuous flow measurements, receiving the discharge from all the hydraulic apparatus; water channels of rectangular, trapezoidal and triangular cross section, rectangular and trapezoidal weirs, fitted to two weir tanks, one iron, the other wood, three impulse water wheels, one small turbine, hydraulic rams, simple, single and duplex steam pumps, direct acting and flywheel, compound Blake pump, single acting, direct acting, triple expansion duplex, low pressure Worthington pump of large capacity and low head, separately steam driven centrifugal Lawrence pump, belt driven centrifugal pump, a high pressure

pump and accumulator of the Worthington type for 1500 lbs., and a second for 5000 lbs. pressure. Two hot air engines, and several internal combustion engines, including the Nash, fitted to operate on various fuels, a Hornsby-Akroyd, an old and a new style Otto, an International Harvester, a stationary and Otto boat engine are equipped for gas engine test and investigation work of great variety. From time to time engines of this class are secured for short periods of time for testing purposes. For the study of refrigeration there is installed a small Brunswick ammonia compression ice-making and refrigerating unit, motor driven, and a larger De La Vergne steam-driven, ice-making plant.

COURSES IN MECHANICAL ENGINEERING

11 or 12, 13-14—Steam Machinery—A descriptive course covering the names, types and functions of the main power units, auxiliaries and their parts; steam engines, steam boilers, steam turbines, steam auxiliaries, including feed pumps and injectors, economizers, condensers, chimneys, mechanical draft appliances, superheaters, steam separators, traps.

Mechanical, Electrical, and Chemical Engineers, No. 11, one hour first term, second year. Mechanical, Electrical, and Chemical Engineers, Nos. 13, 14, one hour throughout third year. Civil Engineers and Chemists, No. 12, one hour second term, third year. Civil Engineers and Chemists, Nos. 13, 14, one hour throughout fourth year. Mining Engineers, Nos. 13, 14, one hour throughout fourth year. Professor Lucke.

15—Valve Gears and Governors—Graphic determination of proportions and computations for design. Designs of steam engine slide valve gears to specification by means of Zenner's, Bilgram's and Sweet's diagrams. Layout of Corliss valve gears, valves, valve gears and cams for gas and oil engines, air compressors, blowing engines and pumps. Computations for inertia and flyball governors, direct and indirect governing gear. One hour and one afternoon, second term, fourth year. Prereq. Mechanical Engineer 13-14-42-46-35-36. Professor Rautenstrauch and Mr. Kunze.

17-18—Applied Thermodynamics—Generation of heat by combustion of fuels. Transformation of heat and work by steam boilers and steam engines, gas and oil engines, air compressors, air, ammonia and carbonic acid refrigeration machinery. Relation between temperatures and quantities of heat. Expansion of solids and liquids. Specific heats of solids, liquids, vapors, gases. Latent heats of fusion and vaporization; properties of steam, saturated, wet or dry. Energy diagrams to temperature entropy and pressure volume co-ordinates. Combustion of fuels, calorific power, evaporative equivalent; air for combusion; weight, temperature, and specific heats of products. Boiler evaporation and efficiency. In-

fluence of grate and heating surface; radiation, fuel, materials of construction, and form. Necessary and accidental chimney losses. Expansion and compression of gases; work done; intrinsic energy, heat gained or lost, efficiency of the transformation. Air compressors; effects on efficiency and work of compression by water jacketing, water injection and inter-cooling. Hot air engines; capacity and thermal efficiency. Expansion of steam, wet, dry and superheated. Changes in quality during expansion. Exponent of expansion line by temperature entropy method. M.E.P., I.H.P., water rate, missing water and thermal efficiency of steam engines. Thermal efficiency of free expansion of steam in turbine nozzles and injectors. The effects on the thermal efficiency of steam engines of cylinder condensation, re-evaporation, steam jackets, superheat, compounding and reheating. Gas and oil engines; thermal efficiency and capacity. Refrigeration methods. Refrigerating effects by evaporation of ammonia and carbonic acid and the expansion of air. Tonnage capacity of refrigeration compressors; efficiency of refrigeration with conditions. Comparison of ammonia compression, carbonic acid compression, ammonia absorption and dense air systems. One hour throughout the third year. Prereq. Mathematics 5-6, Mechanics 5-6. Professor LUCKE.

19-20—STEAM ENGINE DESIGN—Advanced machine design based on the problems involved in the design of the steam engine. Complete design of a steam engine for power economy and regulation. Analysis of stresses in frame, flywheel, shaft, connecting rod, piston rod, cylinder and cylinder heads, steam chest walls and cover. Governors, bearings and lubrication. Graphic analysis of flywheel action and determinations for angular variation. Diagrams of governor action. Design with regard to stress analysis, limitations of shop and foundry facilities, economy in manufacture, interchangeability of patterns. Shop drawings and erection plant. Methods of manufacture; specifications. Two hours and one afternoon, first term. Two hours and two afternoons, second term, Seminar Year. Prereq. Mechanical Engineering 41-42-39-40-37. Professor RAUTENSTRAUCH and Mr. KUNZE.

21-22—GAS ENGINES—Actual and theoretical limitations of the heat effects on perfect gases, gas cycles and engine cycles. Explosive and non-explosive, internal and external methods of heating. Engines operating on internal combustion. Mechanism for using coal, oil and gaseous fuels, with computations of thermal efficiency, H.P. per unit displacement, range of pressure, volume and temperature. Properties of explosive mixtures, limits of proportions, temperature of ignition, rate of propagation, pressures due to explosion. Critical investigation of the development of the modern internal combustion engine by analysis of gas cycles, together with the mechanism for execution and the limits imposed by it. Analysis of U. S. patents in this class. Mechanism and methods for mixing and proportioning, governing, igniting, cylinder

cooling and scavenging. Modern types of gas and oil engines compared. Oil, gasoline, kerosene and alcohol vaporizers. Gas producers for anthracite and bituminous coal, suction and pressure, single and double zone. Regenerators, scrubbers, purifiers, dust cleaners, gas holders, pressure regulators. H.P. and efficiency of modern producers, engines and complete plants and auxiliary parts by computation and by laboratory tests. Drafting room design of complete engine to specifications per H.P., efficiency, regulation, adaptability. Probable M.E.P., diagram factor, piston speed, displacements, clearance volume. Breech end and cylinder form to resist heat and gas pressure stresses and to contain openings for blow off, igniters or starters, piston rod, inlet and exhaust valves, lubrication. Valve location and diameter. Cooling jackets for heads, cylinders, piston and piston rods. Stuffing boxes. Probable indicator cards, maximum gas pressure, inertia diagram, stresses in principal parts, turning effort diagram. Other details as in the steam-engine design course. Three hours and one afternoon laboratory during first term. Two hours and one afternoon drafting room during second term. Prereq. Mechanical Engineering 17-18-41-42-31-32-37. Mechanics 101-102. Professor LUCKE, Mr. PARR and Mr. KUNZE.

25-26—POWER PLANT LAYOUT AND SPECIFICATIONS—The selection of the power system; gas, oil, steam or water. Selection of the number and kind of units to meet conditions. Alternative auxiliaries and specialties. Capacity, efficiency, weight, space, foundations, settings, first cost, maintenance and repair costs, builder's specifications, proposals, purchaser's specifications, and contracts for the main units, auxiliaries and for the complete plant. Boilers and trimmings; grates, furnaces, stokers, flues, stacks, blowers, dampers, damper regulators, coal and ash handling, coal storage, boiler feed pumps, pump governors, injectors. Piping; pipe fittings, valves, pipe covering, packing gaskets. Steam separators; traps. Steam engines and trimmings. Oil separators; filters, and lubricating systems. Water purification systems. Superheaters, drip returns, feed water heaters, economizers, scrapers and fans. Surface and barometric condensers. Circulating, hot well, wet and dry vacuum pumps. Exhaust steam heating. Oil engines, gas engines, producers and auxiliaries. Water wheels and turbines. Pipe lines, flumes, penstocks and water wheel governors. Plant report forms and cost sheets; daily, monthly and yearly load curves. Accounting systems. Power costs.

In the first term the students lay out and trace in the drafting room a complete steam plant with assigned units, consisting of several engines and boilers to operate on a given coal with an assumed daily load curve, providing pumps, stack, and piping, and report on water rate of the engine, efficiency of boilers, with individual load, and water and coal consumption of the plant, daily and yearly, operating power costs, in-

cluding labour, coal, water, maintenance and repair per H.P. hour and per H.P. year, load factor, bill of material for the plant and the probable first cost; interest, depreciation, insurance and other fixed charges; total power cost.

In the second term these plants are exchanged and redesigned for 50% increase of peak load and the maximum possible reduction of power cost by introducing auxiliaries to increase efficiency, such as feed water heaters, economizers, condensers, superheaters or forced draft. Each addition is judged by charging interest, depreciation, operating and maintenance expense of the additions against reduction in fuel and water. Purchaser's specification is drawn up to cover the alteration and builder's proposal form submitted and accepted. These are handed in with all computations and drawings. One hour and one afternoon during the second term. Prereq. Mechanical Engineering 31-32-33-96S-17-18. Professor Lucke and Mr. Kunze.

31-32—Experimental Engineering—Laboratory methods for the determination of experimental data. Derivation of physical laws from experimental results. Comparison of actual performance of machines with computed prediction and evaluation of unknown elements. Methods of approach for the solution of practical problems by experiment and computation. The work is illustrated by problems on the flow of liquids, gases and vapors, combustion, transfer of heat, steam generation and changes of state, transformation of energy, power generation and transmission, energy losses, thermal, hydraulic and mechanical. For each problem a preliminary report is submitted before the test, involving the analysis of the problem, the attempted prediction and the required test log, based on class-room explanations; this is incorporated with the test results and an interpretation of differences between these and the prediction, including judgment of errors, to constitute the final report. The apparatus used for this course includes: Pressure gauges, manometers, thermometers, pyrometers, indicators, tachometers, planimeters, barometers, weirs, channels, nozzles and orifices for water, steam and air, pitot and venturi tubes, steam, gas and water piping and meters, dynamometers, power scales, viscosimeters, flue gas apparatus, friction machines, steam traps, hydraulic ram, steam injectors, air pump, hot air engine, duplex steam pumps, Pelton wheel, centrifugal pump, simple steam engine. One hour and one afternoon during third year. Prereq. Mathematics 5-6, Mechanics 9-101-102, Mechanical Engineering 11, 13, 14. Professor Lucke, Mr. Parr and Mr. Thurston.

33—Experimental Engineering—Continuation of course 31-32. The work of this course is the same in nature as 31-32, but the problems involve more difficult computations and more skilful manipulation of the apparatus. These problems are principally concerned with energy transformation, necessary and accidental losses and the determination

of the conditions affecting performance of compound and triple expansion steam engines and pumps, operating condensing and non-condensing, with and without receivers, with and without reheaters. Hydraulic motors, gas and oil engines, one, two and three stage air compressors, with and without inter-coolers, feed water heaters, fans, steam boilers, Engineering Societies. One hour and one afternoon first term, fourth ammonia refrigerating machines, steam superheaters and condensers. Attention is also given to the commercial tests standardized by the year. Prereq. Mechanical Engineering 31-32-17-18. Professor LUCKE, Mr. PARR and Mr. THURSTON.

35-36—KINEMATICS OF MACHINERY—Motions in machines. Instant centers and velocity ratios. Velocity and acceleration diagrams, their function, graphic determination and integration into force diagrams. Cams, disk, cylindrical and inverse. Gearing; involute and cycloidal in spur, and bevel gears, worm and wheel, skew gears. Chain and belt drive. Trains of mechanism. Graphic determination of pulley sizes. Design of motions to specifications. Graphic determination of stresses in machines and structures. Two hours both terms third year. Prereq. Drawing 5-7, Mathematics 5. Professor RAUTENSTRAUCH and Mr. KUNZE.

39-40—PRINCIPLES OF MACHINE DESIGN—Selection of working stress for materials of machines. Influence of form on shrinkage stresses. Form as a factor in strength, stiffness and economy of material; ribbed and box sections. Axles, shafts, levers and pins. Gear wheels, couplings, clutches, brakes, bolts, keys, pulleys, riveted joints, springs, belting, rope transmission, hydraulic press cylinders, hooks, turbine disks, plain bearings, sliding surfaces, ball and roller bearings, pivot and thrust bearings. Analysis of stresses, practical rules for design and limiting conditions. One hour and one afternoon during first term, third year. Two hours during second term. Prereq. Mechanical Engineering 37-35. Professor RAUTENSTRAUCH and Mr. KUNZE.

41-42—DESIGN OF SPECIAL MACHINERY—Application of kinematics, the principles of machine design and shop and foundry methods to problems in practical design. Layout of mechanisms to fulfil given functions, and clothing same in metal. Designing with reference to strength and stiffness of parts, interference and adjustment, maintenance and repair, appearance, interchangeability, economy in production and shop processes. Complete shop and erection drawings with bill of material, in accordance with modern drafting room systems and standards. Two machines are designed each year. Triplex power pump, shaper, slotter, power punch, shears, boring mill, jib crane, traveling crane, stone crusher, testing machine, brick machine, cotton press, bull dozer. One afternoon first term, third year. Four afternoons second term, third year. Prereq. Mathematics 5-6, Drawing 1-2, Mechanical Engineering 35-36-37. Professor RAUTENSTRAUCH and Mr. KUNZE.

46—HYDRAULIC MACHINERY—*Pumps*—Standard types of pumps and pumping machinery. Special pumps, piston, plunger, rotary, general service, deep-well, wood pulp, hot water, acid, brine, condenser, circulating, vacuum. Educators, ejectors, injectors. Rams, accumulators, relief valves. Forms, characteristics, adaptability, capacity and efficiency. Pump valves and governors. Pumping plants.

Hydraulic Motors and Turbines—Modern types. Pelton impulse wheels, horizontal and vertical shaft turbines, inward and outward flow, action and reaction. Water wheel governors. Calculations on design, H.P. and efficiency. Turbine installations. Three hours second term, third year. Prereq. Mechanical Engineering 101-102. Mr. KUNZE.

52—WORKS MANAGEMENT—Business methods. Methods of manufacture and output affecting systems of management of mills and factories, and cost of production. Departmental division and distribution of authority and responsibility as affecting the directness of producing. Departments of engineering, construction, sales and stores. Executive department. Methods and forms of reports to directors and various departments. Labor accounting systems. Cost determination and selling price. Purchase of raw material and sale of products. Utilization of scrap and waste to product. Layout of mills and character of construction with regard to lighting, heating, ventilation, sanitation, insurance and reduction of fire hazard. Group and individual drive. Principle of mill construction and power. Two hours second term, fourth year. Prereq. 41-42-19. Professor RAUTENSTRAUCH.

56—HYDRO-ELECTRIC INSTALLATIONS—Water power. Modern American water wheels, turbines, governors and water power installations. Critical examination of existing installations for high and low heads. Water supply systems; reservoirs; dams, spillways, forebays, canals, flumes, penstocks, tunnels, pipe lines. Cost of development with local conditions. Water power costs. Laboratory work on water flow and hydraulic motors.

One hour and one afternoon for Electrical Engineers, second term fourth year. Prereq. Civil Engineering 75. Professor LUCKE and Mr. PARR.

69—STEAM MACHINERY—A short course covering the same ground as Mechanical Engineering 11 for Mining Engineers. One hour first term, third year. Mr. PARR.

71—HEAT AND ITS APPLICATION—Fuels for motive power, combustion, transfer of heat, heating surface, generation of steam, chimneys, artificial draft, smoke prevention, use of steam in engines, superheating; gas and air engines, combined vapor engines, ammonia and other vapor engines, air compressors, refrigerating machinery.

Three hours lectures and recitations. For Mining, Civil and Electrical Engineers. Professor LUCKE.

76-77—EXPERIMENTAL ENGINEERING—A short course of one term

(76) similar to 31-32-33 for Civil and Mining Engineers; two terms (76-77) for Electrical Engineers. One hour and one afternoon each term. Professor LUCKE and Mr. PARR.

92S—SHOP PRACTICE—Practical work in shops and manufacturing establishments with a report on the work done and the shop equipment and methods. Six weeks or more during the first summer. Professor RAUTENSTRAUCH and Mr. KUNZE.

94S—DRAFTING ROOM PRACTICE—Practical work in drafting rooms of engineering establishments with a report similar to that for the first summer. Six weeks or more during the second summer. Professor RAUTENSTRAUCH and Mr. KUNZE.

96S—POWER PLANT PRACTICE—Practical work in handling power machinery and log keeping with report on work done and the characteristics of the installation. Six weeks or more during the third summer. Professor LUCKE and Mr. PARR.

99—GRADUATION THESIS—Professional project on approved topic. In this work the student is thrown on his own responsibility to solve a problem of professional grade. This work must be in the nature of experimental research except when otherwise assigned. Topics must be approved before November first, and reading begun at once. Report in standard form must be accepted two weeks before Commencement. Fifteen hours second term, fourth year. Professor LUCKE.

Graduate Courses

201-202—RESEARCH—Special problems and original investigations in advanced mechanical engineering with conferences, laboratory work, and design as required.

Prereq. All courses offered in the department of Mechanical Engineering. Professors LUCKE and RAUTENSTRAUCH.

203-204—MECHANICS OF THE STEAM TURBINE—Velocity and energy of jets of liquids, vapors and gases; influence of nozzle form on weight and velocity of discharge; thermal changes in gases during free expansion; transformation of heat to kinetic energy by jets; application of kinetic energy of liquid or gas jets to moving of bucket-wheels against resistances; stresses in high-speed rotating parts due to speed and temperature; free expansion in stages, effect on angular velocity and efficiencies of rotation; application of principles to turbine design. Professor LUCKE.

205-206—VIBRATION IN MACHINES—Forces due to rotation of masses irregularly distributed in one plane; balancing of rotating systems by one or more new masses; rotation in several planes rotating couples; inertia effects of reciprocating masses; systems with both rotating and reciprocating and irregular moving masses; vibration of supports and framing; vibration of building; synchronism of period of building with period of machine. Professor LUCKE.

PROGRAM OF STUDIES IN THE COURSE OF MECHANICAL ENGINEERING

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Spherical trigonometry (Math. 2)	91	Elements of the dynamo (E. E. 2)	56	D. C. Electric distribution (E. E. 104)	60	Electrical distribution (E. E. 105)	58
Analytical geometry (Math. 3-4)	91	Differential and integral calculus (Math. 5-6)	90	Properties of materials (C. E. 6)	47	Valve gears and governors (M. E. 15)	65
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Gymnasium (Phys. Ed. A)	......	Analytical mechanics (Mech. 102)	91	Workshop economics and specifications (M. E. 52)	70		
Theory of Surveying (C. E. 2)	48	Metallurgy of iron and steel (Met. 4)	39	Thermodynamics (Mech. 106)	91		
Summer work:		Physical laboratory (Phys. 43-44)	91	Analytical mechanics (Mech. 101)	91		
Surveying practice (C. E. 15)	47	Gymnasium (Phys. Ed. B)	......	Steam machinery (M. E. 13-14)	65		
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		Drafting room practice (M. E. 94S)	71	Power plant practice (M. E. 96S)	71		

The First Class is identical for all courses.

SCHOOL OF CHEMISTRY

List of Officers

Charles F. Chandler, M.D., Ph.D., LL.D., Sc.D. . *Mitchill Professor of Chemistry*
Charles E. Pellew, E.M. .... *Adjunct Professor of Chemistry*
Marston Taylor Bogert, A.B., Ph.B., *Professor of Organic Chemistry*
J. Livingston Rutgers Morgan, Ph.D. .... *Professor of Physical Chemistry*
James S. C. Wells, Ph.D. . . *Adjunct Professor of Analytical Chemistry (Qualitative)*
Henry C. Sherman, Ph.D. .... *Professor of Organic Analysis*
Samuel A. Tucker, Ph.B. . . . *Adjunct Professor of Electro-Chemistry*
Victor J. Chambers, Ph.D. .... *Instructor in Organic Chemistry*
Everett J. Hall .... *Instructor in Assaying*
Floyd J. Metzger, Ph.D. .... *Instructor in Analytical Chemistry*
Cavalier Hargrave Joüet, Ph.D. ..... *Tutor in Analytical Chemistry*
Arthur C. Neish, Ph.D. .... *Tutor in Chemistry*
Charles H. Ellard, A.M., *Tutor in Analytical Chemistry (Qualitative)*
Hal T. Beans, Ph.D. ..... *Tutor in Analytical Chemistry (Qualitative)*
Otto Kress .... *Tutor in Chemistry*
William C. Uhlig, Ph.D. .... *Assistant in Analytical Chemistry (Qualitative)*
J. Edwin Sinclair, B.S. .... *Assistant in Analytical Chemistry*
Charles E. Taylor, B.S., A.M. ..... *Assistant in Analytical Chemistry*
Kaufman G. Falk, Ph.D. .... *Assistant in Physical Chemistry*
John N. Pring, M.Sc. .... *Assistant in Electro-Chemistry*
.... *Assistant in Analytical Chemistry (Quantitative)*

General Statement

The regular four-year courses of instruction herein shown are designed for the education of professional chemists who intend to devote their lives to the practice of this profession, either as teachers in colleges and scientific schools, or as chemists or managers in manufacturing and other industrial enterprises.

There are two courses offered, leading to the degrees of Chemist and Chemical Engineer respectively.

Degree of Chemist

The course in Chemistry includes not only all branches of theoretical, analytical, and industrial chemistry, but also collateral sciences, such as mathematics, mechanics, physics, crystallography, blowpipe analysis, mineralogy, metallurgy, mechanical and electrical engineering, and

drawing, which have been found by experience to be required by the professional chemist. It is the intention to provide the graduate not only with a thorough knowledge of the principles and practice of chemistry in all its branches, but with a broad and liberal education in the collateral sciences as will prepare him for every demand that will be likely to be made upon him in connection with his profession or in the pursuit of investigation.

The instruction is by lecture, recitation, and laboratory practice, with periodical examinations, both written and experimental.

Degree of Chemical Engineer

The course in Chemical Engineering is designed to educate chemists with a sufficient amount of engineering to fit them to take charge of chemical works which depend largely on the use of machinery. This requires a knowledge of mechanical engineering, electrical engineering, hydraulics, mechanical drawing, shopwork, etc., as well as a thorough knowledge of chemistry in all its branches. Such an education qualifies a man to act as manager of gas works, sugar refineries, dyeing and calico-printing establishments, electro-chemical works, etc.

Courses in Inorganic Chemistry

1 or 2—General Chemistry—Elementary, designed to serve as an equivalent to the entrance examination in chemistry.

To include the chief physical and chemical characteristics, the preparation and the recognition of the following elements, together with their principal compounds: oxygen, hydrogen, carbon, nitrogen, chlorine, bromine, iodine, fluorine, sulphur, phosphorus, silicon, potassium, sodium, calcium, magnesium, zinc, copper, mercury, silver, aluminum, lead, tin, iron, manganese, chromium, and more detailed study of water, hydrochloric acid, carbon-monoxide, carbon-dioxide, oxides of nitrogen, nitric acid, ammonia, sulphur-dioxide, sulphuric acid, hydrogen sulphide, sodium hydroxide, ammonium hydroxide.

Special attention will be given to the atmosphere (constitution and relation to animal and vegetable life), flames, acids, bases, salts, oxidation and reduction, crystallization, combining proportions by weight and volume, calculations founded on these and Boyle's and Charles' laws, symbols and nomenclature, atomic theory, atomic weights, valency (in a very elementary way), nascent state, natural grouping of the elements, solution (solvents and solubility of gases and solids and liquids, saturation), strength of acids and bases, conservation and dissipation of energy, chemical energy, electrolysis, etc. 3 lectures and 2 afternoons laboratory practice, one-half year. Text-book: Remsen's *Chemistry, Briefer Course,* Dr. Neish.

3-4—General Inorganic Chemistry—Introduction. Laws of chemical combination, history, occurrence, preparation, and properties of the elements and their principal compounds. Text-book: Newth's *Inorganic Chemistry.* 3 lectures and 1 recitation. Professor Chandler and Mr. Kress.

Pre-requisite: Course 1 or 2 or Entrance Examination in Chemistry.

7-8—Inorganic Chemistry—2 hours lectures or conferences throughout the year and 5 afternoons laboratory during the second half-year. Professor Chandler.

Designed for fourth-year students in the course of chemistry selecting a thesis in inorganic chemistry.

101-102—Advanced Inorganic Chemistry—Including the origin and development of the periodic law, and the history and properties of the rare elements. 2 lectures. Professor Pellew.

Pre-requisite: Courses 3-4 and 61-62.

Summer Courses

For details, see the Announcement of the Summer Session.

s1 (s6)—General Chemistry—5 hours lectures, 15 hours laboratory work, and 2 hours recitations. Mr. Williams and Mr. Whitman.

sT—The Principles of Chemistry—5 hours lectures, and 25 hours laboratory work. Dr. Chambers and Mr. Sinclair.

Physical Chemistry

21-22—Elementary Physical Chemistry—3 hours a week in lectures and recitations, second half-year, and laboratory work 15 afternoons each half-year (equivalent to 1 afternoon throughout the year). Text-books: Portions of Morgan's *Physical Chemistry for Electrical Engineers* and Ostwald's *Physico-Chemical Measurements.* Professor Morgan and Assistant.

Pre-requisite: Course 3-4 and Physics 3-4.

121-122—Physical Chemistry—A course treating of the states of aggregation, solution, and ions in analytical chemistry, thermo-chemistry, chemical mechanics, and electro-chemistry. 3 hours lectures and recitations during the entire year, and 15 afternoons, equivalent to 1 afternoon a week, laboratory during the first half-year. Text-books: Morgan's *Elements of Physical Chemistry,* and Ostwald's *Physico-chemical Measurements.* Professor Morgan and Assistant.

Pre-requisite: Course 3-4 and 61-62, Physics 3-4 and Mathematics 5-6.

37—Theoretical Electro-chemistry—2 hours lectures and recitations. Text-book: Portions of *Morgan's Physical Chemistry for Electrical Engineers.* Professor Morgan.

Pre-requisite: Course 3-4 and 65, Physics 3-4, and Mathematics 5-6.

23-24—PHYSICAL CHEMISTRY—2 hours in lectures or conferences throughout the year, and 5 afternoons laboratory during the second half-year. Professor MORGAN.

Designed for fourth-year students in the course of chemistry, selecting a thesis in physical chemistry.

221-222—ADVANCED PHYSICAL CHEMISTRY, LABORATORY COURSE—2 conferences and at least 16 hours in the laboratory throughout the year. Professor MORGAN.

Designed as a major course for candidates for the degree of A.M.
Pre-requisite or parallel: Courses 121-122, 163-164.

223-224—ADVANCED PHYSICAL CHEMISTRY, RESEARCH—Original investigation. Professor MORGAN.

Designed as a major course for candidates for the degree of Ph.D.
Pre-requisite or parallel: Courses 121-122, 163-164.

Summer Courses

For details see the Announcement of the Summer Session.

S37—ELEMENTARY PHYSICAL CHEMISTRY—5 hours. Prof. MORGAN.

RESEARCH—The laboratory is open to properly qualified students for research under the direction of Professor MORGAN.

Organic Chemistry

147-148—ORGANIC CHEMISTRY, ELEMENTARY LECTURE COURSE—An introductory course, which can be taken with advantage by college students and by those expecting to enter the medical course. Instruction given on such important classes of compounds as the hydrocarbons, alcohols, ethers, organic acids, fats, waxes, soaps, cyanides, sugars, carbohydrates, alkaloids, coloring matters, drugs, perfumes, and the like. The lectures will be liberally illustrated by material from the Chemical Museum and by experimental demonstration. Text-book: Remsen's *Organic Chemistry.* 2 hours. Dr. CHAMBERS.

Pre-requisite: Course 3-4. It is urged that, if possible, laboratory work, Course 43-44, be taken with this elementary lecture course.

43-44—ORGANIC CHEMISTRY, ELEMENTARY LABORATORY COURSE—A study of the typical methods for preparation and the typical reactions of the important classes of organic compounds. The laboratory work may be varied depending on the future needs of the student. Text-book: Gattermann's *Practical Methods of Organic Chemistry.* 8 hours. Dr. CHAMBERS.

Pre-requisite or parallel: Courses 3-4, and 147-148.

141-142—ORGANIC CHEMISTRY, GENERAL COURSE—A more comprehensive treatment of the subject, including a discussion of all the

important classes of organic compounds. In the laboratory a large number of typical organic substances are prepared synthetically, and instruction is given in the methods of qualitative and ultimate organic analysis. In addition to this, students taking the course as a partial major for A.M. are required to submit an essay upon some special line of practical work assigned by the instructor. Text-books: Richter's *Organic Chemistry,* Gattermann's *Practical Methods of Organic Chemistry,* Noyes and Mulliken's *Class Reactions and Identification of Organic Substances.* 4 lectures and 1 recitation a week for one year, and 4 afternoons laboratory the first half-year. Professor BOGERT and Dr. CHAMBERS.

Pre-requisite: Courses 3-4, 21-22, 161-162, and Physics 3-4.

143-144—ORGANIC CHEMISTRY, CONFERENCES—Presentation and discussion of recent important investigations in the field of organic chemistry. 2 hours. Professor BOGERT.

Required of all candidates for A.M. or Ph.D., taking major courses in organic chemistry and, together with 5 afternoons laboratory practice the second half-year, of all fourth-year students in the school of chemistry selecting a thesis in organic chemistry. Pre-requisite or parallel: Course 141-142.

241-242—ADVANCED ORGANIC CHEMISTRY, LABORATORY COURSE—An extended practical study of a given group of compounds, or a minor original investigation. Personal instruction, conferences, and laboratory work of not less than 12 hours a week throughout the year. Professor BOGERT.

Pre-requisite: Course 141-142.

243-244—ADVANCED ORGANIC CHEMISTRY, RESEARCH—Original investigation and research. Conferences, private study, and laboratory work. Professor BOGERT.

Pre-requisite or parallel: Courses 101-102, 141-142, 163-164.

Summer Courses

For details see the Announcement of the Summer Session.

s147-148 (s20)—ORGANIC CHEMISTRY—10 hours. Dr. CHAMBERS.

s43-44 (s30)—ORGANIC CHEMISTRY, LABORATORY COURSE. Dr. CHAMBERS.

sF—CHEMISTRY OF NUTRITION—See page 26.

RESEARCH—The laboratory is open to properly qualified students for research under the direction of Dr. CHAMBERS.

Analytical Chemistry

61 or 62—QUALITATIVE ANALYSIS—Lectures, conferences, and laboratory practice. Text-book: Wells' *Inorganic Qualitative Chemical Analysis,* and for reference, Treadwell's *Qualitative Analysis.* 4 lec-

tures or conferences a week and 5 afternoons laboratory practice. Professor WELLS, Mr. ELLARD, Dr. BEANS and Dr. UHLIG.

Pre-requisite: Course 1 or 2 or its equivalent.

65—QUANTITATIVE ANALYSIS, INORGANIC, SHORT COURSE—Text-books: Miller's *Notes on Quantitative Analysis* and Miller's *Calculations of Analytical Chemistry.* 2 hours lectures and recitations, and 2 afternoons laboratory practice. Dr. METZGER and Dr. JOÜET.

The analyses included in this course are: Magnesium sulphate, potassium alum, coal, iron ore, copper, zinc, alkalimetry, acidimetry, and flue gas.

Pre-requisite: Courses 3-4 and 61-62.

66—QUANTITATIVE ANALYSIS, INORGANIC—Text-books: Miller's *Notes on Quantitative Analysis* and Miller's *Calculations of Analytical Chemistry.* 3 lectures or recitations a week, and 6 afternoons laboratory practice during the second half-year. Dr. METZGER, Dr. JOÜET and assistant.

The analyses included in this course are: Magnesium sulphate, potassium alum, iron-ammonium alum, coal, iron ore, pig iron, spiegel, zinc ore, limestone, slag, copper, lead, arsenic, antimony ores, and flue gas.

Pre-requisite: Courses 3-4 and 61-62.

161-162—QUANTITATIVE ANALYSIS, INORGANIC—Text-book: Talbot's *Quantitative Analysis.* 1 hour lecture and 8 hours laboratory work a week. Dr. METZGER and assistant.

Pre-requisite: Courses 3-4 and 61-62.

163-164—QUANTITATIVE ANALYSIS—The classroom work includes not only the methods applied in the laboratory, but discussions of quantitative separations from a theoretical standpoint, and chemical calculations. Text-books: Treadwell's *Quantitative Analysis;* and Miller's *Calculations of Analytical Chemistry.* 4 hours lectures and recitations a week during the second year, and laboratory practice. 5 afternoons for chemists, 4 afternoons for chemical engineers and metallurgists. Dr. METZGER and Dr. JOÜET.

The analyses included in this course are: Magnesium sulphate, sodium or other chloride, potassium alum, iron ammonium alum, coal, iron ore, pig iron, spiegel, limestone, slag, feldspar, ores of zinc, copper, nickel, lead, chromium, arsenic, antimony, alloys, rocks, gas analysis, etc.

Pre-requisite: Courses 3-4 and 61-62.

167-168—ADVANCED INORGANIC ANALYSIS—2 lectures a week throughout the year. Laboratory practice 3 afternoons during the first half-year for students taking the course in Metallurgy, and 5 afternoons during the second half-year for students in the course of Chemistry, who elect thesis work in inorganic analytical chemistry. Dr. METZGER.

In the first half-year, systematic volumetric analysis and technical analytical methods connected with iron, steel, copper, lead and zinc metallurgy. In the second half-year, rock analysis and the analytical chemistry of the rare elements.

Pre-requisite or parallel: Chemistry 101-102, 121-122, 163-164.

261-262—QUANTITATIVE ANALYSIS—Special methods, gravimetric, volumetric, and electrolytic. Conferences and laboratory work at least 16 hours a week. Dr. METZGER.

Pre-requisite: Courses 3-4, 61-62, 161-162.

263-264—RESEARCH—Conferences and laboratory work for 20 hours a week.

Original investigation in inorganic analysis or inorganic chemistry. Dr. METZGER.

Pre-requisite or parallel: Course 167-168.

171—QUANTITATIVE ANALYSIS, ORGANIC AND SANITARY—The lectures include, in addition to the methods used in the laboratory, the interpretation of results in food and water analysis and discussions of the analytical chemistry of carbohydrates and fats. Text-books: Sherman's *Methods of Organic Analysis* and Mason's *Examination of Water;* for reference, Richards and Woodman's *Air, Water and Food.* 4 hours and laboratory work 6 afternoons for chemists, 3 afternoons for chemical engineers, 3 to 6 afternoons for graduate students. Professor SHERMAN and assistant.

The analyses included in this course are: Acidimetry and alkalimetry, alcohol, glycerol, formaldehyde, sugars, cream of tartar, milk, butter, fatty and lubricating oils, soap, paint, asphalt, fertilizers, and the sanitary analysis of water.

Pre-requisite: Courses 3-4, 61-62, 161-162 and 41-42.

173-174—ADVANCED ORGANIC ANALYSIS—2 hours throughout the year and laboratory work during the second half-year, 5 afternoons for fourth-year students in the Chemistry course who elect thesis work in organic analytical chemistry or food chemistry. Professor SHERMAN.

The analytical chemistry of proteids and their derivatives, alkaloids, tannins and fibres; plant analysis; advanced methods in food analysis; measurement of the activity of enzymes and the digestibility and nutritive value of food; systematic review or organic analysis.

Pre-requisite or parallel: Course 171 (or equivalent work in 271-272).

271-272—SPECIAL METHODS OF ORGANIC ANALYSIS AND FOOD INVESTIGATION—Conferences and laboratory work, 16 hours a week. Professor SHERMAN.

Pre-requisite: Courses 3-4, 61-62.

273-274—RESEARCH—Conferences and laboratory work 20 hours a week.

Original investigation in organic analysis or food chemistry. Professor SHERMAN.

Designed as a major course for candidates for the degree of Ph.D.
Pre-requisite or parallel: Course 173-174.

69 or 170—ASSAYING—Ores and metallurgical products. Text-book: Ricketts' and Miller's *Notes on Assaying.* 2 lectures or recitations a week, and laboratory practice, during the first half-year for mining engineers and metallurgists; during the second half-year for chemists. Mr. HALL.

The assays included in this course are: Preliminary (reagents, etc.); lead and tin ores; gold and silver ores, pure and impure, including galena, stibnite, arsenopyrite, blende, pyrite, tellurides, etc.; mattes and tailings; corrected assays and extraction tests; gold, silver, and lead bullions.

Laboratory work for mining engineers and metallurgists, 3 afternoons during the first half-year; for chemists, 3 afternoons during the second half-year.
Pre-requisite: Course 3-4, 61-62, and Mineralogy 1-2 or 7-8.

160—SPECIAL METHODS OF ASSAYING ORES, ALLOYS, AND FURNACE PRODUCTS—Comparison of methods and determination of losses. Conferences and laboratory work at least 8 hours a week for one half-year. Mr. HALL.

Pre-requisite: Courses 3-4, 61-62, and Mineralogy 1-2 or 7-8.

Summer Courses

For details, see the Announcement of the Summer Session.

s61-62 (s7)—QUALITATIVE ANALYSIS—7 hours lectures and conferences, and 30 hours laboratory work a week. Dr. BEANS.

s161-162 (s19)—QUANTITATIVE ANALYSIS—5 hours lectures and 30 hours laboratory work a week (accepted for Course 65). Dr. JOÜET.

sF—CHEMISTRY OF NUTRITION—5 hours lectures. Professor SHERMAN.

s171a (s13a)—ORGANIC AND SANITARY ANALYSIS—Conferences and laboratory work 12 to 30 hours a week. Professor SHERMAN and assistant.

RESEARCH—The laboratory is open to properly qualified students for research. In analytical chemistry or the chemistry of foods under the direction of Professor SHERMAN.

Industrial Chemistry

81-82—INDUSTRIAL CHEMISTRY, GENERAL COURSE—The subjects discussed are: (1) Air: nature, sources of contamination, sewer gas, plumbing, draining, disinfection, ventilation. (2) Water: composition of natural waters, pollution, disposal of sewage and house refuse. (3)

Artificial illumination: candles, oils and lamps, petroleum, gas and its products, electric light. (4) Limes, mortars, and cements. (5) Building-stones: decay and preservation. (6) Timber and its preservation: pigments, paints, essential oils, varnishes, preserving processes. (7) Explosives: gunpowder, gun-cotton, nitro-glycerine. (8) Glass and ceramics. (9) Electro-metallurgy. (10) Photography. Text-books: Park's *Hygiene* and Wagner's *Chemical Technology*. 3 hours lectures. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Course 3-4.

83-84—INDUSTRIAL CHEMISTRY, SPECIAL COURSE—The subjects discussed are: (1) Chemical manufactures: acids, alkalies, and salts. (*a*) Sulphur, sulphurous acid, hyposulphites, sulphuric acid, bisulphide of carbon. (*b*) Common salt, soda ash, hydrochloric acid, chlorine, binoxide of manganese, bleaching powder, chlorates, chlorimetry. (*c*) Carbonate of potash, caustic potash. (*d*) Nitric acid and nitrates. (*e*) Iodine, bromine. (*f*) Sodium, aluminum, magnesium. (*g*) Phosphorus, matches. (*h*) Ammonia salts. (*i*) Cyanides. (*j*) Alum, copperas, blue vitriol, salts of magnesia, baryta, strontia. (*k*) Borates, stannates, tungstates, chromates. (*l*) Salts of mercury and silver. (*m*) Oils, fats, soaps, and glycerine. Text-books: Wagner's *Chemical Technology;* Lunge's *Manufacture of Sulphuric Acid and Soda.* 3 lectures. Given alternate years. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Courses 3-4, 81-82.

85-86—INDUSTRIAL CHEMISTRY, SPECIAL COURSE (*continued*) (2) Food and drink: milk, cereals, starch, bread, meat, tea, coffee, sugar, fermentation, wine, beer, spirits, vinegar, preservation of food. (3) Clothing: textile fabrics, bleaching, dyeing, calico printing; paper, tanning, glue, india-rubber, gutta-percha. (4) Fertilizers: guano, superphosphates, poudrettes. Text-books: Wagner's *Chemical Technology;* Lunge's *Manufacture of Sulphuric Acid and Soda;* Schultz' and Julius' *Kuenstlichen Organischen Farbstoffe;* Schultz' *Chemie des Steinkohlentheers.* 3 hours lectures. Given alternate years. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Courses 3-4, 81-82.

87 or 88—INDUSTRIAL CHEMISTRY, LABORATORY PRACTICE—Preparation of inorganic chemicals, including the preparation and purification of chemical reagents, pigments, and salts of the rare as well as of the common metals. 3 afternoons. Professor PELLEW.

Pre-requisite: Courses 3-4, 61-62.

89—INDUSTRIAL CHEMISTRY, LABORATORY PRACTICE—Special applications: Textile industry, vegetable and animal fibres, bleaching, dyeing, and calico printing. 1 afternoon a week. Professor PELLEW.

Pre-requisite: Course 3-4, 61-62, 147-148.

91-92—Chemical Microscopy—The use of the microscope for the identification of crystalline chemical compounds, fibres, starches, urinary sediments, micro-organisms, etc., with special application to the detection of poisons and food adulterants. 4 hours laboratory practice a week. Professor Pellew.

95-96—Industrial Chemistry—2 hours throughout the year, and 5 afternoons in the laboratory during the second half-year. Professor Pellew.

Designed for fourth-year students in the course of chemistry selecting a thesis in industrial chemistry.

97—Chemical Factory Apparatus and Machinery—3 hours.

To cover the construction and use of pumps, tanks, filter presses, evaporating pans, grinding and other chemical machinery. (*To be given in* 1908-09.)

98—Cost of Chemical Operations in Factories—3 hours.

To include: Methods of determining costs as affected by the price of fuel, of labor, of repairs, and by interest charges. Dependence of cost upon locality, price of transportation and size of plant. Average cost of such operations as evaporation, filtration, moving solutions, etc. (*To be given in* 1909.)

295-296—Industrial Chemistry, Advanced Course—Original research; the study and investigation of methods and processes in sanitary and industrial chemistry. Personal instruction and laboratory work for one year. Professor Pellew.

Designed as a major course for candidates for the degree of Ph.D. Pre-requisite or parallel: Courses 101-102, 121-122, 141-142, 163-164.

93-94—Electro-chemistry—2 hours in lectures or conferences throughout the year, and 5 afternoons in the laboratory during the second half-year. Professor Tucker.

Designed for fourth-year students in the course of chemistry selecting a thesis in electro-chemistry.

181 or 182—Practical Electro-chemistry—Electro-plating, influential factors in electrolysis, electrolysis with molten electrolytes, the use of diaphragms, electrolytic preparations, electric furnace practice. 5 afternoons. Professor Tucker.

Pre-requisite: Courses 3-4, 61-62, 65.

183-184—Industrial Electro-Chemistry—Theory and practice of electrolysis, electro-deposition, electric smelting and refining, primary and secondary batteries, production, preparation and purification of chemicals and metals. 1 hour and the equivalent of 14 afternoons laboratory work. Professor Tucker.

Pre-requisite: 3-4, 65.

281-282—Electro-chemical Research—Original investigation and research equivalent to 16 hours a week during one year. Professor Tucker.

Pre-requisite: Course 181 or 182.

283-284—Advanced Electro-chemical Research—Private study, original investigation and research for two years. Professor Tucker.

Pre-requisite: Course 181 or 182.

80a—Factory Inspection and Summer Memoir—Second Year.

Visiting and inspection of chemical works of special interest in and near New York City, such as gas works, petroleum refineries, sugar houses, dyeing and calico-printing establishments, paint and varnish factories, soap, candle and oleomargarine works, paper mills, and plants for the purification of water and sewage. Professor Pellew.

Also a memoir descriptive of some chemical process, the subject to be assigned to each student.

Required of all second-year students in the course of chemistry. The visits to factories are made during the two weeks preceding Commencement. The memoir must be wholly completed by December 1st.

80b—Factory Inspection and Summer Memoir—Third Year.

Similar to 80a, excepting that the memoir covers description, working plans, and full estimate of cost of a chemical laboratory, according to outlines assigned to each student. Professor Pellew.

Required of all third-year students in the course of chemistry.

N.B. A student failing to hand in his completed memoir by December will be obliged to pay a fee of $5.00, as for a special examination.

ENGINEERING DRAFTING

List of Officers

Ralph E. Mayer, C.E. .... *Adjunct Professor*
Samuel O. Miller, C.E. .... *Tutor*
Thomas H. Harrington, C.E. .... *Tutor*
Morris F. Weinrich, Mech.E. .... *Assistant*

General Statement

The courses of instruction under this department include all drafting and descriptive geometry as required in the first and second years of the Schools of Mines, Chemistry and Engineering.

The instruction is by lecture, recitation and drafting-room exercises, with periodical examinations.

Courses in Drafting

1-2 (*a*)—Elements of mechanical drafting—Use of instruments; plane problems; freehand lettering; dimensioning

(*b*)—Projections—Orthographic projection; intersections; developments; problems in descriptive geometry

(*c*)—Machine drafting—Conventional signs for materials of construction; sketching of machine details. Working drawings; tracings; blue printing

(*d*)—Topography—Conventional signs; hill shading; mapping.

1 hour lecture first half-year, and 6 hours drafting. Professor MAYER, Mr. MILLER, and Mr. HARRINGTON.

3-4—Descriptive geometry—Problems on point, line, and plane; classification of surfaces; tangent planes to single curved surfaces and surfaces of revolution; intersections; developments; warped surfaces. 1 hour, first half-year, and 2 hours second half-year. Professor MAYER, Mr. MILLER and Mr. HARRINGTON

5-6 (*a*)—Graphics—Shades and shadows; perspective; isometric projection; cabinet projection.

(*b*)—Stone cutting—Buttress; wing-wall; arches.

1 hour lecture and 5 hours drafting. Prof. MAYER and Mr. MILLER.

7-8 (*a*)—Structural drafting—Standard rolled sections; conventional riveting signs; standard connections; methods of framing and detailing structural work; beams; columns; plate girder; roof trusses; bridge details.

(*b*)—Machine drafting—Working drawings; tracing and blue prints of machine details; boiler and engine-room layouts, etc.

1 hour lecture and 5 hours drafting. Professor MAYER, Mr. MILLER, and Mr. HARRINGTON.

Equipment

The drafting rooms and offices, situated on the fourth floor of the Engineering building, are equipped with a standard form of drafting table, and having a seating capacity for 150 students.

The collections of the department contain a complete set of models illustrating problems in projections and descriptive geometry, as well as the usual charts, blue prints, and models for use in the lecture and drafting rooms. A special feature of the collection is a full set of Olivier models illustrating the warped surfaces and problems in intersections and tangencies.

PROGRAM OF STUDIES IN THE COURSE OF CHEMICAL ENGINEERING

First Class	Page No.	Second Class	Page No.	Third Class	Page No.	Fourth Class	Page No.
General inorganic chemistry (Chem. 3-4)	75	Elementary organic chemistry (Chem. 41-42) and S. 43-44	76	Industrial chemistry, special (Chem. 83-84)	81	Industrial chemistry, special (Chem. 85-86)	81
Qualitative analysis (Chem. 61-62)	77	Industrial chemistry (Chem. 81-82)	80	Assaying (Chem. 170)	80	Industrial chemistry laboratory (Chem. 88 or 182)	81
Spherical trigonometry (Math. 2)	91	Quantitative analysis (Chem. 163-164)	78	Quantitative analysis, organic (Chem. 171)	79	Physical chemistry (Chem. 121-122)	75
Analytical geometry (Math. 3-4)	91	Elements of electrical engineering (E. E. 1)	56	Electrical engineering lectures (E. E. 56)	57	Chemical factory apparatus and machinery (Chem. 97-98)	82
a Elements of mechanical drawing...... Freehand lettering.. *b* Projections .... *c* Machine drawing—sketches, tracing.. *d* Topography .... } Draw. 1-2	84	Elements of the dynamo (E. E. 2)	56	Electrical engineering laboratory (E. E. 58)	......	Industrial chemistry laboratory (Chem. 89)	81
Descriptive geometry (Draw. 3-4)	84	Differential and integral calculus (Math. 5-6)	90	Analytical mechanics (Mech. 101)	91	Experimental mechanical engineering (M. E. 33)	68
Elementary mechanics (Mech. 9)	......	General physics (Phys. 3)	91	Metallurgy of copper (Met. 1)	39	Machine design (M. E. 41)	69
Theory of surveying (C. E. 1-2)	48	Analytical mechanics (Mech. 102)	91	General metallurgy (Met. 2 *a*)	39	Shop methods for economical production (M. E. 52)	70
Gymnasium (Phys. Ed. A)	......	Structural drawing (Draw. 7-8)	84	Metallurgy of lead (Met. 2)	39	Heat and its applications (M. E. 71)	70
General physics (Phys. 3-4)	91	Forging (Shop wk. 3)	93	Properties of materials (C. E. 6)	47	Metallurgy of iron and steel (Met. 4)	39
Summer work: Surveying practice (C. E. 15)	47	Bench-work, machine-tool work (Shop wk. 4)	93	Testing of materials (C. E. 7-8)	47	Metallurgy laboratory (Met. 71-72)	41
				Experimental mechanical engineering (M. E. 31-32)	68	Hydraulics (C. E. 75)	49
				Mechanics of materials (M. E. 37)	......	Thermodynamics (Mech. 7)	91
				Engineering design and drawing (M. E. 39)	69	Thesis	......

The First Class is identical in all courses.

PROGRAM OF STUDIES IN THE COURSE OF CHEMISTRY

First Class	Page No.	Second Class	Page No.	Third Class	Page No.	Fourth Class	Page No.
General inorganic chemistry (Chem. 3-4)	75	Elementary physical chemistry (Chem. 21-22)	75	Industrial chemistry (special) (Chem. 83-84)	81	Industrial chemistry, special (Chem. 85-86)	81
Qualitative analysis (Chem. 61-62)	77	Elementary organic chemistry (Chem. 147-148)	76	Industrial chemistry laboratory (Chem. 88)	81	Industrial chemistry laboratory (Chem. 89)	81
Spherical trigonometry (Math. 2)	91	Industrial chemistry (Chem. 81-82)	80	Chemical microscopy (Chem. 91-92)	92	Physical chemistry (Chem. 121-122)	75
Analytical geometry (Math. 3-4)	91	Quantitative analysis (Chem. 163-164)	78	Advanced inorganic chemistry (Chem. 101-102)	75	Organic chemistry (Chem. 141-142)	76
Draw. 1-2: *a* Elements of mechanical drawing...... Freehand lettering.. *b* Projections .... *c* Machine drawing—sketches, tracing.. *d* Topography	84	Elements of electrical engineering (E. E. 1)	56	Assaying (Chem. 170)	80	Chemistry 7-8, or 23-24, or 93-94, or 95-96, or 143-144, or 167-168, or 173-174	75 to 79
Descriptive geometry (Draw. 3-4)	84	Elements of the dynamo (E. E. 2)	56	Quantitative analysis, organic (Chem. 171)	79	The steam engine and boiler (M. E. 13-14)	65
General physics (Phys. 3-4)	91	Differential and integral calculus (Math. 5-6)	90	Industrial electro-chemistry (Chem. 183-184)	82	Metallurgy of silver, gold, zinc (Met. 3)	39
Theory of surveying (C. E. 1-2)	48	General physics (Phys. 3)	91	Engineering of power plants (M. E. 12)	65	Metallurgy of iron and steel (Met. 4)	39
Gymnasium (Phys. Ed. A)	......	Gymnasium (Phys. Ed. B)	......	Analytical mechanics (Mech. 102-101)	91	Thesis	......
Summer work:				Metallurgy of copper (Met. 1)	39		
Surveying practice (C. E. 15)	47			General metallurgy (Met. 2 *a*)	39		
				Metallurgy of lead (Met. 3)	39		

The First Class is identical in all courses.

OTHER COURSES

Prescribed for the Degrees Offered Under the Faculty of Applied Science

COURSES IN ASTRONOMY

105—GEODESY—Brief history of geodetic operations and description of theodolites, base apparatus, and other instruments used in geodetic work, including their adjustment and use. Reference books: Clarke's *Geodesy, United States Coast Survey Reports,* Jordan's *Handbuch der Vermessungskunde,* and Wilson's *Topographic Surveying.* 2 hours. Dr. MITCHELL.

106—GEODESY—The applications of practical astronomy to geodetic surveying, and training in methods of accurate computation. Text-books: Campbell's *Practical Astronomy,* Doolittle's *Practical Astronomy.* 2 hours. Dr. MITCHELL.

107—GEODESY—Summer Courses in Practical Geodesy: Given in the field, each student making his own observations and calculations. The outline work is:

I.—1. Use of the Ephemeris. 2. Conversion of mean time into sidereal time and *vice versa*, and apparent time into mean time and *vice versa*. 3. Values of level divisions obtained by means of the "level trier." II.—Sextant. 1. Construction of the instrument. 2. Theory of the instrument. 3. Adjustments. (*a*) Angle measuring. (*b*) Time by altitudes of the Sun. (*c*) Time by equal altitudes of the Sun. (*d*) Latitude by altitudes of Polaris. (*e*) Latitude by altitudes of the Sun. (*f*) Latitude by circum-meridian altitudes of the Sun or stars. (*g*) Time by altitudes of stars. III.—Transit instrument, clock and chronograph. 1. Construction. 2. Theory of instruments. 3. Adjustments. 4. Star lists and tables. 5. Observations and reductions for constants and time error of clock. IV.—Base measuring. 1. Construction of apparatus. 2. Adjustments. 3. Measurement of a base and reduction of observations. V.—Angle measuring by "directions." 1. Construction of instrument. 2. Adjustments. 3. Observations and reductions. VI.—Determination of the true meridian, and the azimuth of a line. 1. Theory of methods. 2. Observations and reductions. VII.—Barometric hypsometry. 1. Constructions of instruments. 2. Adjustments. 3. Formulæ and tables. 4. Observations and reductions.

Six weeks of practical work from June 1, at Osterville, Mass. Professor JACOBY and Dr. MITCHELL, with Assistants.

Pre-requisites for all courses: Mathematics of first two years.

109—GEODESY—Gives the derivation of the formulæ used in the summer course work, the adjustment of observations, and is followed by several lectures on descriptive astronomy. Text-book: Doolittle's *Practical Astronomy.* 2 hours. Dr. MITCHELL.

Courses in Botany

7—GENERAL BOTANY—(1) The principal features of plant structure and plant evolution, 1 hour lecture, and (2) Dendrology; the characters and identification of native trees and the structure of timbers, 1 afternoon in field or laboratory. Professor UNDERWOOD and Mr. DARLING.

COURSES IN GEOLOGY

4—Petrography—A short course in the microscopic study of rocks. 2 lectures and 1 afternoon, two months of the second half third year. Dr. Berkey

Pre-requisite: Mineralogy, 6

5-6—General Geology—First half-year physical geology, with practical work in the rock collections under the lithological part of the subject; second half-year, stratigraphical and historical geology, involving laboratory work with type fossils and collections illustrating the geology of the United States. Text-books: Scott's *Introduction to Geology;* Kemp's *Hand-book of Rocks.* 3 hours lectures, second year. Professor Kemp, Dr. Berkey, and Professor Grabau

16—Index Fossils—A study of the invertebrate fossils characteristic of the various geologic horizons of North America

Pre-requisite: Mineralogy 1-2

18—General Geology—A general discussion of dynamical, structural and historical geology, with practical work in the rock collections and assigned field work on Saturdays during the last six weeks. Special course for students in Civil Engineering during the second half-year only. Dr. Berkey.

19—Physiographic and Applied Geology—A study of topographic and structural features and their representation on maps; application of geologic principles to engineering enterprises; water supply; illustrative problems. Open to students having completed a course in general geology. Dr. Berkey.

105-106—Economic Geology—First half-year, discussion of the general features and formation of ore bodies, followed by a description of the deposits of the ores of iron, copper, lead, zinc, silver, gold, and the lesser metals, with especial reference to North America; second half-year, a description of the distribution and occurrences of coal, petroleum, natural gas, asphalt, building-stone, water supply, salines, and minor minerals. Text-book: Kemp's *Ore Deposits of the United States and Canada,* and lecture notes privately printed. 3 hours lectures and conferences, third year. Professor Kemp

Pre-requisites: Geology, 103-104

107-108—Invertebrate Palæontology—First part of the course deals with the principles of palæontology; methods of study of the ontogeny of hard parts of animals, and the laws of morphogenesis. This is followed by a consideration of the classes of invertebrates important from a palæontologist's point of view, emphasis being laid on the features which show genetic relationship. Special attention is given to groups whose evolution has been worked out. Text-book: Zittel-

Eastman, *Text-book of Palæontology*, Vol. I. 2 hours lecture and 4 hours or more laboratory. Professor GRABAU and Mr. BROWN.

110—GEOLOGICAL EXAMINATIONS AND SURVEYS—A discussion of the methods of systematically recording and interpreting geological phenomena; and of the organization and scope of geological surveys on a larger scale. This is followed by a sketch of the history and results of state and national geological surveys in this and other countries; and of other sources of detailed information regarding local geology. 2 hours, second half fourth year. Professor KEMP

Pre-requisites: Geology 105-106

201-202—PETROLOGY—A discussion of the origin, microscopic structure, and mineralogical composition of the crystalline rocks, and of metamorphism. 2 hours lectures and 4 hours laboratory, fourth year. Professor KEMP

Pre-requisite: Mineralogy 6

112—FIELD GEOLOGY—A summer course of a week or ten days is held in connection with the summer courses in practical mining, usually near the location of the latter work. The same work is repeated near New York for students in the course of Mining Engineering who are not required to do the work in practical mining. Graduate students in the department may join either one or both of these parties. Instruction is given in the field in observing, recording, and interpreting geological phenomena and in the preparation of maps and sections. A written report is required.

205-206—COMPARATIVE GEOLOGY OF NORTH AMERICA—A description and a study of the geological formations of America, their areal distribution and time relations, the various schemes of classification, the character of the rocks, the typical forms of life, and the unheavals and igneous intrusions of each period. Special emphasis is laid on palæogeographic development of North America. Text-books: *The Correlation Bulletins of the U. S. Geological Survey,* the *manuals* of Dana and Geikie, and the various state and national *survey reports.* 3 hours lectures, and at least 4 hours laboratory and reading. Professor KEMP for the crystalline rocks, Professor GRABAU for the sedimentary.

303-304—JOURNAL CLUB AND SEMINAR, conducted by the officers of the department weekly, as arranged by consultation.

COURSES IN MATHEMATICS

1—ALGEBRA, GENERAL THEORY OF EQUATIONS (Wells' *College Algebra*)—2 hours, first term of first year. Professor KEYSER, Mr. MITCHELL, Dr. LING, Mr. GRAY, and Mr. HOOK

Pre-requisites: Entrance Mathematics

2—Spherical Trigonometry (Davies' *Legendre*)—2 hours, second term of first year. Professor Keyser, Mr. Mitchell, Dr. Ling, Mr. Gray, and Mr. Hook

Pre-requisites: Entrance Mathematics

3-4—Analytical Geometry (Wentworth's)—3 hours, first year. Professor Keyser, Mr. Mitchell, Dr. Ling, Mr. Gray, and Mr. Hook

Pre-requisites: Entrance Mathematics

5-6—Differential and Integral Calculus (Osborne's)—3 hours, second year. Professors Van Amringe, Fiske, Maclay, and Keyser

Pre-requisites: Mathematics 1, 2 and 3-4

COURSES IN MINERALOGY

6—Optical Mineralogy—Principles, apparatus, and distinguishing characters of minerals in thin sections. 2 afternoons laboratory work for two months of second half of third year. Professor Luquer and assistant

Pre-requisites: Mineralogy 1-2.

1-2—Descriptive and Determinative Mineralogy—First half-year: The elements of crystallography. The use of the blowpipe in determination of silicates and borates. Second half-year: The blowpipe analysis of ores and other substances, and the study of the important economic minerals. This course considers mineralogy from a practical standpoint, the purpose being: 1st. Sight recognition of average specimens of all common or economically important species; 2d. Rapid determination of the less characteristic specimens by simple tests; 3d. Familiarity with economic characters. 3 hours lectures and conferences, 2 afternoons laboratory. Professor Moses, Professor Luquer and assistants.

Pre-requisites: Entrance requirements in Chemistry and Physics

5—The Minerals of Building Stones—Study of common species, their properties, methods of determination, and their economic effect on building stones. 2 hours lectures and 1 afternoon laboratory during first half-year. Professor Luquer and assistant.

Prescribed for students in the course of Civil Engineering.

6—Optical Mineralogy—Principles, apparatus, and distinguishing characters of minerals in thin sections. Second half-year, first seven and a half weeks. Professor Luquer and assistant.

Pre-requisite: Course 1-2 (first term), or its equivalent.

In sections, 2 afternoons per week.

Prescribed for students in Mining and Metallurgy.

Consists principally in the determination of minerals in rock sections by the aid of the polarizing microscope. It supplements courses 5 and 1-2 and is preliminary to geology 4 (petrography).

7-8—MINERALOGY AND CRYSTALLOGRAPHY—Blowpipe analysis of minerals and compounds; sight recognition and determination of economic minerals; inspection and measurement of crystals; determination of optical constants of crystals. 3 hours lectures and conferences, 2 afternoons laboratory. Professor MOSES, Professor LUQUER and Mr. LAMME.

Prereq. as for 2-1.

Prescribed for all students taking the degree of Chemist.

15-16—MINERALOGY—Sight recognition and determination of minerals important in the chemical industries. 1 afternoon laboratory. Professor MOSES and assistant.

Pre-requisites: Chemistry A and Physics A.

COURSES IN PHYSICS AND MECHANICS

PHYSICS 3—General Physics, sound, light and heat. 3 hours. Professor TUFTS, Drs. DAY, PEGRAM and DAVIS, and Mr. WOODMAN.

PHYSICS 4—General Physics, Mechanics, properties of matter, electricity and magnetism. 3 hours. Professor TUFTS, Drs. DAY, PEGRAM and DAVIS, and Mr. WOODMAN.

PHYSICS 43-44—Laboratory course of 4 hours. Professor PARKER and Dr. PEGRAM.

PHYSICS 105—Critical discussion of measurements and computations. 3 hours. Professor PARKER.

MECHANICS 7—THERMODYNAMICS, with special reference to its bearing on the theory of heat engines—2 hours, first half fourth year. Professor WILLS.

102-101—ANALYTICAL MECHANICS—Kinematics, Statics, and Kinetics of the particle and of rigid bodies. Ziwet's *Theoretical Mechanics* is used as a text, and is supplemented by lectures on special topics, such as the theory of stresses, and the solution of certain differential equations. While particular attention is given to the fundamental principles of mechanics, students in this course are required to solve a large number of problems affording actual applications of the principles. Lectures, written recitations, and discussions of problems. 3 hours, second half of second year and first half of third year. Professor PFISTER and Dr. PEGRAM.

MECHANICS 106—Thermodynamics with special reference to heat engines. 3 hours. Professor WILLS.

MECHANICS 107—Elements of electro-mechanics, electric, magnetic and electro-dynamic, potential and induction, application to the ideal dynamo. 2 hours. Professors PUPIN and WILLS.

MECHANICS 108—Electro-mechanics, Hopkinson's Theory of Dynamo and Motor Designing, and Frölich's Method of Dynamo and Motor Testing. 3 hours. Professors PUPIN and WILLS.

MECHANICS 109—Theory of alternators and transformers. 3 hours. Professor PUPIN.

MECHANICS 110—Theory of variable currents, theory of polyphase, high frequency and high potential currents. 2 hours. Professor PUPIN.

MECHANICS 205-206—Electricity and Magnetism. Electro-magnetic theory of light. 2 hours. Optional. Professor PUPIN in 1906-7. Professor WILLS, 1907-8.

MECHANICS 207-208—Partial Differential Equations of Physics. Optional. Professors WILLS and PUPIN, as above.

In all cases those courses in Mathematics, Mechanics and Physics which, according to the curriculum, should precede any course in Mechanics or Physics are to be considered its pre-requisites.

Pre-requisites: Physics 3-4, Mathematics 5-6.

COURSES IN SHOP WORK

Given by the Department of Manual Training, Teachers College.

Equipment

THE WORK-SHOPS are located in the Macy Manual Arts Building of Teachers College, 120th Street, and may be generally divided into two groups, each having a capacity for twenty workers at one time. The wood-working course is planned to lead up to pattern-making and foundry-work. The equipment includes benches for joinery and pattern-making with the necessary hand-tools, and speed lathes for wood-turning. The foundry division has facilities for bench and floor moulding and for limited work with sweeps. A carpenter shop with saw-benches, planers and tools for profile-sawing is available for working up stock and special appliances.

The second division includes the shops for metal-working. For blacksmith work and forging are twenty Buffalo forges with anvils, tools, and vises. A 30-pound Bradley power-hammer and a 400-pound Billings and Spencer drop-press are used to illustrate and enforce the application of the forge processes to manufacturing.

For metal-working by hand a special shop is equipped with vises for chipping, filling, scraping, and general bench-work. For machine-tool work a well-equipped shop contains engine-lathes, swinging from twelve to twenty inches, planers, shapers, drill-presses, universal milling machine, universal grinding machines and the subsidiary appliances of the machine shop. A Jones and Lamson flat turret-lathe, and a Warner

and Swasey screw machine are used to familiarize the student with modern methods of rapid and economical production, and he is expected to learn their use in manufacturing processes. The tool room is administered according to advanced standards in these matters, the attendance record is kept by a Willard & Frick time-keeper's recording clock, and a regular shop organization and atmosphere is aimed at.

1-2—Carpentry, framing, and joinery, first half-year; wood-turning and pattern-making second half-year. 2 afternoons shop practice. Mr. WEICK.

2S—Pattern-making and foundry-work. 100 hours in 3 weeks in June. Mr. WEICK. Pre-req. 1-2.

3—SECOND-YEAR SHOP-WORK—Forging, management of fire, shaping, drawing, upsetting, swaging, welding, tempering and die-forging. During the last three weeks of the course practice is had in forging by drop and machine hammer. 1 hour lecture; 200 hours shop practice during the year. Mr. SLEFFEL.

4—Bench-work, chipping, filing, tapping and threading, pipe threading, scraping and fitting. Machine-tool work at lathe, planer, drill, shaper, milling machine, grinder, and turret-lathe. Assembling, erection, and rigger's work. 1 hour lecture; 100 hours shop practice during the year. Mr. BENNS.

4S—Machine-tool and Forge work continued. 100 hours in three weeks in June. Mr. BENNS and Mr. SLEFFEL. Prereq. 3-4.

5l—THIRD-YEAR SHOP-WORK—Machine-tool work, with special appliances for rapid and economical production. 2 afternoons. Mr. BENNS. Pre-req. 4 and 4S.

7-8—Carpentry, framing, and joinery, first half-year; wood-turning, pattern-making, moulding, and foundry-work, second half-year. 1 afternoon shop practice. Mr. WEICK. Short course for electrical and civil engineers.

9-10—Bench-work and vise-work, chipping, filing, threading and tapping, forging and blacksmith work, swaging, welding and tempering, first half-year; machine-tool work at lathe, planer, shaper, slotter, and milling machine, second half-year. 1 hour lecture and the equivalent of 1 afternoon shop practice. Mr. BENNS and Mr. SLEFFEL. Short course for students in electrical and civil engineering.

GENERAL INFORMATION REGARDING COLUMBIA UNIVERSITY

Students under the Faculty of Applied Sciences may enjoy every advantage to be derived from the resources of the University. The University occupies thirty-five buildings, and its grounds cover thirty-five acres. The number of officers of instruction in 1906-7 was 562, and of resident students 4611.

University Library

The Library is open each week day (except Thanksgiving, Christmas, Good Friday, and Independence Day) from 8.30 A.M. until 11 P.M., October-June; and until 10 P.M., July-September. All students and graduates have free access to the Library and may draw books for home use.

The Library contains about 400,000 volumes, exclusive of unbound pamphlets and duplicates, and about 30,000 German dissertations. It is catalogued both by authors and by subjects. The catalogue is on cards accessible to readers.

Gymnasium

The Gymnasium is open daily during the academic year, except on Sundays and legal holidays, from 9.30 A.M. to 7 P.M., Saturdays to 6 P.M. It is closed for the entire day only on Thanksgiving, Christmas, New Year's, and Good Friday. On all other holidays it is open from 2 to 6 P.M. At least one of the instructors is on the floor at all times when the Gymnasium is open.

Every student is entitled to a physical examination by the Medical Director. On the basis of this examination advice is given as to the kind and amount of exercise best adapted to his needs. For the Gymnasium fee see page 15.

The main exercising room is 35 feet high, semicircular in shape, and has an area of 16,000 square feet. It is well lighted and well ventilated. The running track is 11 feet wide, with ends raised, and measures 10 laps to the mile. On the same floor with the running track are the offices, rooms for fencing, boxing, and handball, two large dressing-rooms with 1,804 steel lockers, and 32 shower-baths. Below the exercising room is the swimming pool, semicircular in shape and 100 feet by 50. The depth is from 4 to 10 feet. Around the pool are the dressing-rooms, and shower-, needle-, and tub-baths. On this floor also are rooms for the use of the various athletic teams.

Work in the gymnasium to the extent of two hours a week for two years is prescribed for students in Applied Science. A physical exam-

ination is required for each student upon entrance and at the end of this prescribed work.

The work prescribed for these classes is arranged with a view to securing three definite ends: first, health; second, strength, control, efficiency, and endurance; third, erect carriage and correct position of the head, shoulders, and chest. Students are marked upon the basis of attendance, effort, and knowledge of the subjects taught, and a passing mark is necessary for a degree.

There are on South Field a practice field for baseball, lacrosse, and football, a running track, nine tennis courts, and eight outdoor handball courts.

Committee on Employment for Students

It is the design of the Employment Committee to give to students desiring to work their way through college the opportunity to earn enough for their partial or complete support, or, if possible, to extend assistance to them in other ways. Some of the openings available are: private tutoring, translating, addressing, copying of various sorts, teaching in the evening schools, stenography, and typewriting. During the year 1905-06 the student earnings reported to the Committee amounted to $104,240.39. Communications should be addressed to the Committee.

While much work is found for students each year, preference is naturally given, in case of a choice of applicants for a position, to those who have spent at least a portion of a year at Columbia, and thus have become personally known to members of this Committee or to other officers, and to those who, as strangers in New York, are not likely to hear of positions through other channels. No prospective student should come to Columbia expecting to depend entirely or even largely upon the assistance of the Committee, and every student should be prepared to meet at least the expenses of the first half-year—say two hundred and fifty dollars.

The chiefs of clinics in the Medical School give advice without charge to students on the lists of the Committee.

There are also Appointment Committees whose duty it is to recommend graduates for teaching or other positions in colleges and universities and to assist competent men to obtain such positions.

Medical Visitor

For the benefit of those members of the University who are without family physicians in New York City, the Trustees have designated a Medical Visitor, whose duties are to render medical assistance to such students as may desire it, either at their homes or elsewhere, for a remuneration to be arranged between himself and individual patients. The medical visitor is Dr. D. S. D. Jessup, whose office hours are from 5 to 6 daily, at 301 West 108th Street (telephone, 2741 Riverside).

University Commons

The University Commons for the accommodation of the men living in the Residence Halls is conducted upon a system combining *table d'hôte* and *à la carte*. The Commons, which has accommodations for 450 men, is in University Hall and is open daily from 7.30 A.M. to 7 P.M. Under the same management is a large buffet lunch room.

Residence Halls

Hartley Hall, a memorial to the late Marcellus Hartley, and Livingston Hall, named in memory of Robert R. Livingston, of the class of 1765, University dormitories on South Field, with accommodations for 500 men, were opened in September, 1905. Each building is 10 stories in height exclusive of basement, and 137 feet long by 60 feet wide. They are lighted throughout by electricity and heated by steam, with telephone connection on each floor. There are four electric passenger elevators.

The two Halls contain 600 rooms, both single and double, all being outside rooms; their arrangement permits of flexibility in renting the rooms in suites. The average size of the bedrooms is about 8 feet by 14.6. The studies average 10 by 14.6 feet. All rooms are nine feet high. Each bedroom has a clothes-closet and an enamelled basin with hot and cold water, and is provided with heavy oak furniture. There are four shower-baths on each floor.

The only entrance to each building for students is on the side facing the campus, and leads directly into an assembly room 60 feet square. This room runs up through two stories and has a large open fireplace opposite the entrance.

While Hartley Hall and Livingston Hall are open to all male students of the University, students in Columbia College, in accordance with the desire of the donors, Mrs. Helen Hartley Jenkins and Mr. Marcellus Hartley Dodge, '03, are given the preference in the assignment of rooms in Hartley Hall.

The average weekly charge for a single room is $3.30, or $129 for the academic year of thirty-nine weeks. A pamphlet containing floor plans of the buildings and indicating the charge for each room may be had upon application to the Secretary of the University. The pamphlet contains also the Hall Regulations. Rooms will be assigned in the order of receipt of applications therefor. All such applications should be made in writing on a blank which will be provided by the Superintendent of Buildings and Grounds.

Other Living Accommodations

Besides these dormitories, there are many good boarding-houses and apartments near the University. The careful selection, inspection, and

registration of such lodgings, etc., have been undertaken, and a card-catalogue of apartments, rooms, etc., is kept at Earl Hall.

Public Lectures

In addition to the regular courses of instruction, numerous public lectures are given each year by the University. Within the past three years the students of the University and their friends have, among others, been addressed by Professors Wilhelm Bjerknes, Wilhelm Ostwald, Ettore Pais, Ambassador Bryce, Professor Karl Lamprecht, the Archbishop of Canterbury, Sir Frederick Pollock, Professors William H. Welch, Lorenz, Hermann Schumacher, Otto Lummer, Larmor, William James, President Wilson of Princeton University.

Relations with Other Institutions

The University maintains close relations with the other educational and public institutions of the city, and properly qualified students of the College enjoy unusual privileges at the Metropolitan Museum of Art, the American Museum of Natural History, the New York School of Philanthropy, and the several theological seminaries in or near the city. Students of the University are also frequently given the opportunity to enjoy the most important dramatic and musical performances of the year at a considerably reduced cost. Full information upon these matters is to be found in the University Catalogue for 1906-07, pages 31-32.

St. Paul's Chapel

St. Paul's Chapel, the gift of Olivia Egleston Phelps Stokes and Caroline Phelps Stokes, as a memorial to their parents, was dedicated February 3, 1907. The Chapel is in the form of a cross, the greatest length being 122 feet and the width at the transepts 77 feet. In all 1,050 sittings are provided. Of these, 120 are in the choir, which, as in the English cathedrals, may itself be used for a religious service at which the attendance is small.

Service, at which attendance is voluntary, is held every week-day except Saturday, at noon, the period from 12 to 12.20 being set apart by the University for religious exercises; and on Sunday afternoons at 4 P.M. There are also frequent organ recitals in the Chapel.

Earl Hall

Earl Hall, the home of the religious, philanthropic, and social organizations and interests of the University, is open from 8.30 A.M. to 10 P.M. daily, to all students without expense, under the direct management of the Secretary of Earl Hall, who is also Secretary of the University Young Men's Christian Association.

The building may not be used for distinctly dogmatic or denominational religious teaching. All organizations the objects of which are to promote the religious and philanthropic life of their student members and of the student body at large have the privilege of holding their meetings in this building. While the social purposes of the Hall are necessarily subordinated to the other uses of the building, the Secretary desires to promote the same type of informal personal and social intercourse that prevails in a good club.

Provision for the regular meetings of student organizations is made, on a day-and-hour schedule, without exclusive use of any of the rooms, in the following order: Societies the purpose of which is (1) primarily religious; (2) primarily philanthropic; (3) primarily literary; and (4) miscellaneous student organizations.

Student Organizations

Academic control of all student organizations, athletic and other, which in any way represent the University before the public, is vested in the University Committee on Student Organizations, appointed by the President. The various organizations, while self-governing, are subject to the regulations of the Committee in respect to their organization, financial management, administration and discipline. The times and places of all public contests and performances must be approved by the Committee. All budgets for expenditure must be approved by the Comptroller of Student Organizations, an officer appointed by the President, and each organization is required to keep an accurate record of its financial operations in the office of the Comptroller. The University Committee on Athletics, also appointed by the President, consisting of three graduates, two students and two officers of the University, has authority to adopt and administer rules of eligibility not involving questions of scholarship and to govern the participation of the students of Columbia University in inter-collegiate athletics. Participation in athletics without the approval of the Committee is forbidden. A pamphlet containing the regulations for student organizations may be obtained from the Secretary of the University.

COLUMBIA COLLEGE

The attention of students is called to the new program of studies in Columbia College by which it becomes to the advantage of the student to enter the courses in Applied Science through Columbia College rather than direct from the secondary school.

While six years are ordinarily required to complete this combined course, it may, under certain conditions, be completed in five years. The student obliged to complete his residence in the shorter period can do so without prejudice to his professional course, but his choice of electives in the College will necessarily be somewhat restricted. He

will, however, have a large advantage over the student entering directly upon the professional course without any previous collegiate training and it is hoped that many for whom the six-year course is impossible will avail themselves of this opportunity. In this case the student should note the following suggestions:

(1) He should become a candidate for the degree of Bachelor of Science in Columbia College rather than for the degree of Bachelor of Arts.

(2) He should include among the subjects for entrance to the College:

Entrance Requirements	Prescribed for Bachelor's Degree	
Elementary Chemistry and Elementary Physics	= Natural Science A	8 points
Advanced Mathematics	= Mathematics A	6 "
Elementary and Intermediate German, or Elementary and Intermediate French	= German A and B or French A and B	12 "

This will anticipate 26 of the 64 "points" of credit prescribed for the Bachelor's degree in Columbia College. (A "point" is normally the equivalent of one hour's attendance at lectures or recitations for a half-year.)

(3) During the first two years at Columbia the 72 points (including all prescribed work) required of candidates who wish to exercise the option of combining collegiate and professional courses may be made up without undue strain as follows:

(*a*) The remaining courses prescribed for the B.S. degree:

English A and B	10 points
History A	6 "
Philosophy A	6 "
Physical Education A and B	4 "
4 half-year courses in Science (which may be so chosen as to satisfy certain prescribed first year work of the professional school), aggregating at least	12 points

leaving 34 to be satisfied under (*b*) and (*c*).

(*b*) A limited number of non-technical electives, among which a course in General Economics and in French or German (unless the intermediate requirement in each has been presented at admission) is strongly recommended.

(*c*) Certain additional collegiate electives identical with the remaining first-year courses of the professional school not satisfied by the prescribed work in science mentioned under (*a*).

The student will then be ready to enter the second year of any of the professional courses without conditions: in fact, with a credit for Physical Education B, and to complete the requirements for such professional course in three years. He will receive credit for the degree of B.S. at the end of the fourth year.

The Degree of Master of Arts

The attention of candidates for a professional degree in Applied Science is called to the following provision:

Students holding college degrees, who shall have completed with marked distinction one of the regular courses in the School of Mines, the School of Chemistry, or the Schools of Engineering may be recommended for the degree of Master of Arts; provided that in each case the candidate, while pursuing his professional course, shall have taken additional work, under the direction of the Faculty of Pure Science, to the extent of a minor subject, for not less than one academic year.

Every such candidate shall present an essay on some topic previously approved by the professor in charge of his minor subject. Before the candidate is admitted to examination the professor in charge of his major subject must have signified his approval of such essay. This essay must be presented not later than May 1 of the academic year in which the examination is to take place.

The Faculty of Pure Science has charge of all advanced work leading to the degrees of Master of Arts and Doctor of Philosophy in the physical sciences (chemistry, physics, and chemical physics); in the mathematical sciences (pure mathematics, mechanics, mathematical physics, astronomy, and geodesy); and in the natural sciences (mineralogy, lithology, geology, bacteriology, botany, zoölogy, palæontology, physiological chemistry, and physiology); and in engineering (civil, sanitary, mechanical, electrical, and mining) and in metallurgy. The requirements for these degrees and a list of subjects which may be offered for them will be found in the *Announcement of the Faculty of Political Science, Philosophy and Pure Science.*

FELLOWSHIPS

For information as to the fourteen University Fellowships of the annual value of $650 each, and the several endowed fellowships open to qualified candidates for the degree of Master of Arts and Doctor of Philosophy, see the Announcement of the Faculties of Political Science, Philosophy, and Pure Science, or the University Catalogue.

The three following fellowships are of particular interest to students of Applied Science.

Tyndall and Barnard Fellowships

The Tyndall Fellowship for the Encouragement of Research in Physics, endowed by Professor John Tyndall, and of an annual value of $648, and the Barnard Fellowship for Encouraging Scientific Research, endowed by the bequest of the late President Barnard, annual value $500, are awarded annually under the following conditions: The Tyndall Fellowship is available for one or more American pupils who may have shown decided talent in physics, and preferably such as shall express the determination to devote their lives to the advancement of theoretic science and original investigations in that department of learning, and is awarded either to a graduate of the University or to a student in it (not necessarily a candidate for a degree) upon the recommendation of the head of the department of Physics. The Barnard Fellowship is awarded upon the joint recommendation of the Faculties of Columbia College, Applied Science, and Pure Science to a graduate of any one of them who, having shown decided aptness for physical investigation, is disposed to devote himself thereto for some years continuously. The recommendation must in each case be made to the President on or before April 1. The appointment is for the term of one year, but the incumbent shall be eligible to reappointment.

It is the duty of a John Tyndall or Barnard Fellow to devote himself faithfully to the investigation of some subject in physical science at this University, or at some other in this country or abroad, under the supervision of some known physicist approved by the President and the head of the department of Physics. He shall make a report, certified to by the physicist superintending and directing him, quarterly to the President, giving an account of the work in which he has been engaged during the three months preceding.

Adams Research Fellowship

The Ernest Kempton Adams Research Fellowship, founded by Mr. Edward Dean Adams in memory of his son, Ernest Kempton Adams, is of an annual value of $1250. The appointment may be made from among the Faculty, teaching staff, alumni, or students of Columbia University. The incumbent of the fellowship shall prosecute researches either in Columbia University or elsewhere, in the physical sciences, in psychology, or in their practical applications. The results of the investigations of the incumbent of the fellowship are published and distributed by the University under the title of "Researches of the Ernest Kempton Adams Research Fellows of Columbia University."

SCHOLARSHIPS

Thirty-five scholarships of the annual value of $250 each are available annually for award to meritorious candidates for professional degrees in Applied Science, who are in good academic standing, and in need of pecuniary aid.

Applications for these scholarships should be made in writing, on blanks which will be furnished for the purpose by the Secretary of the University, and should be filed with him on or before May 1.

The awards will be made not later than July 1 by the Committee on Scholarships. Scholarships not allotted at this time, or becoming vacant, shall be filled by the Committee at its discretion.

One half the actual value of the scholarships will be paid at the opening of the academic year, one half at the beginning of the second half-year. Scholars will be required to pay the tuition fees and all other fees.

Scholarships granted in the first year of a student's connection with the University shall be for a half-year only, and shall be continued to those candidates only who have maintained a satisfactory academic standing during that period. Students already holding scholarships in any year must make application in the regular form if they desire to be considered for the succeeding year. No student already holding a scholarship can be considered as a candidate for a second one in that same year.

In recognition of the liberal gifts for the purchase of the site on Morningside Heights which have been received from J. Pierpont Morgan, Cornelius Vanderbilt, D. Willis James, Morris K. Jesup, Samuel D. Babcock, Oswald Ottendorfer, and others, the Trustees have established a number of scholarships, twenty-seven of which are open to students in the Schools under the Faculty of Applied Science, as follow: seven Morgan, seven Vanderbilt, ten James, one Jesup, one Babcock, and one Ottendorfer. These scholarships may be awarded to students who have been in the University for at least one year.

In addition to the above, eight Faculty scholarships may be awarded to members of any class.

For details concerning the Richard Butler Scholarship, open to male students born in Ohio, see the *Annual Catalogue of Columbia University*, 1905-6, page 477.

MEDALS AND PRIZES

Barnard Medal

A gold medal valued at $200, established by the provisions of the will of President Barnard and endowed by him, known as the "Barnard Medal for Meritorious Service to Science," is awarded quinquennially at Commencement to such person, if any, whether a citizen of the United States or of any other country, as shall within the five years next preceding have made such discovery in physical or astronomical science, or such novel application of science to purposes beneficial to the human race, as in the judgment of the National Academy

of Sciences of the United States shall be esteemed most worthy of such honor. The next award will be made in 1910. For a list of previous awards see the *Annual Catalogue of Columbia University* for 1905-6.

Illig Medals

A bequest of $2000 left by William C. Illig, E.M., '82, provides for the annual award of medals at Commencement to the student or students in the graduating class of the Schools under the Faculty of Applied Science who shall, in the judgment of the Faculty, have merited the same by commendable proficiency in their regular studies.

Darling Prize

The Edward A. Darling Prize in Mechanical Engineering, the income of $1000, bequeathed by Edward A. Darling, formerly Superintendent of Buildings and Grounds, shall be awarded annually to the most faithful and deserving student of the graduating class in mechanical engineering, the recipient to be chosen by ballot by members of the graduating class in the Course in Mechanical Engineering from among three names to be chosen by the Faculty of Applied Science.

Academic Calendar

1907—1908

1907—July 9, Tuesday, Eighth Summer Session opens.

August 17, Saturday, Eighth Summer Session closes.

September 10, Tuesday, Last day for filing applications for September entrance examinations.

September 16, Monday, Entrance examinations, and examinations for deficient and debarred students begin.

September 18, Wednesday, Registration begins.

September 24, Tuesday, Registration ceases for students previously matriculated. Later applications received only upon payment of an additional fee of $5.

September 25, Wednesday, First half-year, 154th year, begins. Scholars to report themselves as in residence to the Registrar. Registration ceases for students matriculating for the first time. Later applications received only upon payment of an additional fee of $5.

November 5, Tuesday, Election Day, holiday.

November 28, Thursday, to November 30, Saturday, inclusive, Thanksgiving holidays.

December 21, Saturday, to January 4, 1908, Saturday, inclusive, Christmas holidays.

1908—January 13, Monday, Last day for filing applications for mid-year entrance examinations.

January 20, Monday, Mid-year entrance examinations begin.

January 22, Wednesday, Mid-year examinations begin in all Schools except Medicine.

February 1, Saturday, First half-year ends.

February 3, Monday, Second half-year begins. Scholars to report themselves as in residence to the Registrar. Registration ceases for students entering the second half-year. Later applications received only upon payment of an additional fee of $5.

February 22, Saturday, Washington's Birthday, holiday.

April 16, Thursday, to April 20, Monday, inclusive, Easter holidays.

May 1, Friday, Last day for filing applications for Scholarships.

May 11, Monday, Final examinations for candidates for graduation begin.

May 24, Sunday, Baccalaureate service.

May 25, Monday, Class Day.

May 26, Wednesday, Commencement Day.

May 28, Thursday, Final Examinations begin.

May 30, Saturday, Memorial Day, holiday.

June 10, Wednesday, Second half-year ends.

June 15, Monday, Examinations of the College Entrance Examination Board begin. For dates of last days for filing applications, see Document No. 19, issued by the Board, Post-Office Sub-station 84, New York, N. Y.

July 7, Tuesday, Ninth Summer Session opens.

August 15, Saturday, Ninth Summer Session closes.

September 14, Monday, Entrance examinations, and examinations for deficient and debarred students begin.

September 16, Wednesday, Registration begins.

September 22, Tuesday, Registration ceases for students previously matriculated. Later applications received only upon payment of an additional fee of $5.

September 23, Wednesday, First half-year, 155th year, begins. Scholars to report themselves as in residence to the Registrar. Registration ceases for students matriculating for the first time. Later applications received only upon payment of an additional fee of $5.

A PARTIAL LIST

OF

GRADUATES OF THE SCHOOLS OF MINES, ENGINEERING AND CHEMISTRY

OF

COLUMBIA UNIVERSITY

NEW YORK CITY*

*The Alumni Association of the Schools of Applied Science of Columbia University publishes every two years a list of graduates, members of the association, in which the professional record of each graduate is given in detail.

ABENDROTH, WILLIAM P., E.E., ... 1904
Gen. Ry. Signal Co., Buffalo, N. Y.

ABRAHAM, HERBERT, B.S. (Chem.), ... 1903
Chemist, Standard Paint Co., Bound Brook, N. J.

ACKER, ALBERT J., E.E., ... 1904
With Crocker-Wheeler Co., Ampère, N. J.

ADAMS, MASON TYLER, E.M., ... 1901
Pres., Britannia Smelting Co. & Man. Div. Britannia Copper Syndicate, Ltd., Britannia Beach, B. C.

ADAMS, RANDOLPH, E.M., ... 1883
Gen. Mgr., Tennessee Copper Co., Copperhill, Polk Co., Tenn.

AGER, JOHN W., MECH.E., ... 1903
Dept. Elect. Eng., Massachusetts Institute of Technology.

AGNEW, J. CARSON, E.M., ... 1904
Asst. Gen. Mgr., Mahoning Ore & Steel Co., Hebbing, Minn.

ALDRIDGE, WALTER HULL, E.M., ... 1887
Gen. Mgr., Con. Min. & Smelting Co. of Canada, Ltd., Trail, B. C.

ALEXANDER, LUDEWELL B., MECH.E., ... 1904
Asst. Eng., United Eng. & Con. Co., on Penn. Tunnels, New York City.

ALSBERG, JULIUS, A.B., MECH.E., ... 1901
With John Bogart, Con. Eng., New York City.

AMY, ERNEST JULIUS HYACINTHE, A.B., E.M., ... 1885
Banker, N. Y. City.

ANDERSON, NORMAN GLENN, E.M., ... 1905
Engineer, Davis-Daly Co., Butte, Mont.

ANDREWS, WILLIAM C., E.E., ... 1905
Engineer, Gen. Elec. Co., Schenectady, N. Y.

Ansbacher, Louis A., Ph.B., ... 1892
Chemist, Ansbacher & Co., Color Mfrs., New York City.

Aplington, Henry W., E.M., ... 1903
Eng. Dept., Hudson Companies, New York City.

Appleby, W. R., A.M. (Associate), ... 1887
Professor of Metallurgy & Dean of Minnesota School of Mines, Minneapolis, Minn.

Arendt, Morton, E.E., ... 1898
Instructor in Elect. Eng., Columbia University.

Atha, Henry Gurney, Ph.B., ... 1889
Treas., The Atha Tool Co., Newark, N. J.

Austen, Peter Townsend, Ph.B., Ph.D., ... 1872
Consulting Chemist, New York City.

Aylmer-Small, Sidney, E.E., ... 1899
Practicing Elect. Eng. & Instr. in Physics, etc., Trinity School, New York City.

Bacon, Daniel R., E.E., ... 1904
Eng. Dept., Brooklyn Edison Co.

Balch, Samuel Weed, E.M., ... 1883
Consulting Mech. & Elect. Engineer, New York City.

Baldwin, William M., Ph.B., ... 1884
Pres. N. Y. Tanning Extract Co., New York City.

Baldwin, William S., E.M., ... 1903
Gen. Mgr., Kerber Min. Co., Villa Grove, Colo.

Bamberger, Sidney M., E.M., ... 1904
Mgr., Bingham Min. Cos., Kaysville Brick Co. & V. Pres., Salt Lake & Ogden Ry. Co., Salt Lake City, Utah.

Banks, John Henry, E.M., Ph.D., ... 1883
Consulting Eng., Chemical, Metallurgical & Mining Work, New York City.

Bardwell, A. F., E.M., ...
Assayer & Chemist, Aspen, Colo.

Barling, Harry Brewster, E.M., ... 1903
Supt., Columbus Borax Co., Griffen, Cal.

Barlow, Elbert S., E.E., ... 1900
V. Pres., Reinforced Cement Const. Co., New York City.

Barnaby, James Christy, Mech.E., ... 1906
Testing Plant, U. S. Geol. Survey, St. Louis, Mo.

Barnard, Edward Chester, E.M., ... 1884
Chief Topographer U. S. Geological Survey.

*Barnett, L. H., E.M., ... 1894
295 Columbus Avenue, New York City.

Barnett, Meyer, E.E., ... 1904
With Gen. Elec. Co., Schenectady, N. Y.

BARRATT, EDGAR GRANT, C.E., ... 1884
V. Pres., Union Bag & Paper Co., New York City.
BARUS, CARL, PH.D. (Associate), ... 1877
Dean Graduate Department, Brown University, Providence, R. I.
BATES, PUTNAM A., E.E., ... 1897
Consulting Engineer, 42 Broadway, New York City.
BATESON, CHARLES E. W., E.M., ... 1902
V. Pres., Josephine Mills, New York City.
BAUERNEBLE, A., JR., E.M., ... 1905
Mining Engineer, Miller-Nye Co., Nevada.
BAUMANN, A. P., E.M., ... 1899
Mining Engineer, Griffen, Cal.
BAUMGARTEN, CHARLES, E.E., ... 1904
With Hawkins Iron Con. Co., New York City.
BAXTER, HAROLD, E.M., ... 1906
Mining Engineer, Gold Fields, Nevada.
BAXTER, GEORGE S., A.B., E.M., ... 1868
In Lumber & Railroad Business, 17 William Street, New York City.
BAYLES, FREDERICK P., E.M., ... 1895
Fuel Expert, Am. S. & R. Co., Denver, Col.
BAYNE, HOWARD, E.E., ... 1901
Treas., Columbia Trust Co., New York City.
BEANS, HAL TRUMAN, B.S., A.M. (Univ. of Nebraska), PH.D. 1904
Tutor Anal. Chem., Columbia University, New York City.
BEARD, JAMES THOM., E.M., C.E., ... 1877
Assoc. Editor, Mines & Minerals, Scranton, Pa.
BEATTY, ALFRED CHESTER, E.M., ... 1898
Consulting Mining Engineer, 71 Broadway, New York City.
BECHSTEIN, CHARLES A., PH.B. (Chem.), ... 1888
Consulting Chemist, 2 West 82d Street, New York City.
BECK, OSCAR CHARLES, B.S. (Chem.), ... 1899
Chemist, H. R. Worthington Plant, Harrison, N. J.
BECKER, RUDOLPH C., B.S., C.E., ... 1906
Asst. Eng., Ashokan Reservoir, N. Y.
*BEEBE, ALFRED L., PH.B., ... 1880
BEHRMAN, GEORGE WILLIAM, C.E., ... 1893
Asst. Eng., Dept. Public Works, Brooklyn, N. Y.
BELLINGER, HIRAM PAULDING, C.E., ... 1887
Supt., The Colvay Process Co., Syracuse, N. Y.
BELLMAN, J. J., E.E., ... 1897
Eng. & Con. Power Plants, 149 Broadway, New York City.
BENEDICT, ELI, B.S., ... 1899
Architect, New York City.
BENEDICT, F. NORTHROP, C.E., ... 1904
Asst. Eng., N. Y. & L. I. R. R. Co.

BENEDICT, WILLIAM DE LIESSELINE, E.M., ... 1874
Consulting Mining Engineer, 43 Cedar Street, New York City

BENHAM, WEBSTER LANCE, C.E., ... 1905
Civil Engineer, Oklahoma City.

BENJAMIN, MARCUS, PH.B., A.M., ... 1878
U. S. National Museum, Washington, D. C.

BENOLIEL, SOL. D., E.E., ... 1896
Gen. Mgr., International Chem. Co., Camden, N. J.

BERG, WILLIAM N., B.S. (Chem.), ... 1904
Asst., Physiological Chemistry, Columbia University, New York City.

BERGER, JOHN, B.S., C.E., ... 1899
Asst. Eng., N. Y. C. & H. R. R. R., New York City.

BERLINER, RICHARD W., MECH.E., ... 1901
Mech. Eng., V. J. Hedden & Sons Co., New York City.

BERNHEIM, GEORGE B., B.S., ... 1901
Chemist, R. Neumann & Co., Hoboken, N. J.

BERRY, EDWIN STEWART, E.M., ... 1905
Asst. to Con. Eng. to M. Guggenheim's Sons, New York City.

BERRY, GEORGE, C.E., ... 1888
Asst. Eng., Bureau of Highways, Borough of Brooklyn, New York City.

BERRY, WILTON GUERNSEY, PH.B., ... 1886
Chemist, U. S. Laboratory, New York City.

BEYER, ALBIN H., JR., C.E., ... 1903
Gen. Prac. as Civ. Eng., 510 Warwick Street, Brooklyn, N. Y.

BIEN, JOSEPH RUDOLPH, E.M., ... 1887
Sec., Julius Bien & Co., New York City.

BIGELOW, LEM C., MECH.E., ... 1904
Representative, Morse Chain Co., New York City.

BINION, JOSHUA, B.S., C.E., ... 1895
Civil Engineer, Johannesburg, Transvaal, S. A.

BIRD, HARRISON K., E.E., ... 1898
Broker, New York City.

BISHOP, ROY NELSON, E.M., ... 1902
Supt., Balaklava Copper Co., Kennett, Cal.

BISHOP, R. R., E.E., ... 1897
Eng., American Telephone and Telegraph Co., Troy, N. Y.

BLACK, ADOLPH, C.E., ... 1894
Adj. Prof., Civil Engineering, Columbia University, New York City.

BLAKE, EDWIN MORTIMER, E.M., PH.D. (1893), . . . 1890
Professor of Mathematics and Mechanical Engineering, University of Arizona, Tucson, Ariz.

Bleecker, C. P., E.M., ... 1881
Supt. and Eng. for R. G. Packard Co., 130 Pearl Street, New York City.

Bleich, Samuel D., B.S., C.E., ... 1902
Asst. Eng., R. T. Com., New York City.

Bleyer, Arthur, E.E., ... 1905
With Oberg & Blumberg, Con. Engrs., New York City.

Blossom, Francis, C.E., ... 1891
Engineer and Contractor, Sanderson & Porter, New York City.

Bode, Wm. Adolph, C.E., ... 1905
Draftsman, Consolidated Gas Co., New York City.

Boecklin, Werner, Jr., C.E., ... 1891
Consulting Engineer, Industrial & Power Plant Engineering, New York City.

Bogert, Marston T., A.B., Ph.B., ... 1894
Professor of Organic Chemistry, Columbia University, New York City.

Bolles, M. N., B.S., Ph.D., ... 1903
Metallurgist, A. S. & R. Co., Monterey, Mex.

*Book, Dwight Dana, C.E., E.E., ... 1890

Bookman, S. (Associate), Ph.D., M.A., ... 1891
Physiological Chemist, Mt. Sinai Hospital, New York City.

Booraem, Robert Elmer, E.M., ... 1878
Consulting Mining Engineer, 19 West 31st Street, New York City.

Bostwick, William Arthur, Met.E., ... 1898
Chief Metallurgist, Carnegie Steel Co., Pittsburg, Pa.

Bradley, Alonzo B., E.E., ... 1903
Engineer, Constr. Dept., Gen. Elect. Co., Schenectady, N. Y.

Bradley, Stephen Rowe, Jr., Ph.B., ... 1890
Treas., Fibre Conduit Co. and V. Pres. Rockland Light & Power Co., Nyack, N. Y.

Bradley, Walter E. F., E.E., ... 1905
Engineer with Peter Cooper Hewitt, New York City.

Brady, Thos. J., Jr., ... 1906
V. Pres. of The Thos. J. Brady Co., New York City.

Brandon, Vivian I., E.E., ... 1901
With N. Y. Telephone Co., New York City.

Braschi, Victor Manuel, Ph.B., E.M., C.E., ... 1881
Consulting Engineer, Rand Drill Co., City of Mexico, Mexico.

Breneman, Harry C., B.S. (Chem.), ... 1902
Factory Mgr., Chas. C. Breneman & Co., Cincinnati, Ohio.

Brereton, Thomas J., A.B., C.E., ... 1883
Engineer, Cumberland Valley Railway, Chambersburg, Pa.

Brewster, Henry Draper (Associate), ... 1883
Brewster & Co., 47th Street and Broadway, New York City.

BRIESEN, HAROLD V., E.E., ... 1901
Engineer, Am. Telephone & Telegraph Co., New York City.
BRINLEY, JOHN ROWLETT, C.E., ... 1884
Civil and Landscape Engineer, 156 Fifth Avenue, New York City.
BRITTON, HENRY B., MECH.E., ... 1902
Mech. Eng., 255 West 75th Street, New York City.
BRITTON, NATHANIEL LORD, A.M., PH.D., ... 1879
Director in Chief, N. Y. Botanical Gardens, New York City.
BRODIE, ORRIN L., C.E., ... 1901
Asst. Eng., Board of Water Supply, New York City.
BROWN, ALEXANDER, E.M., ... 1897
Builder, New York City.
BROWN, ROBERT GILMAN, A.B., E.M., ... 1889
Mgr. Republican Min. & Der. Co., California.
BROWN, STANLEY, E.E., ... 1902
Mgr. N. Y. office Western Electric Co., New York City.
BUCKLEY, CHARLES RAMSAY, A.B., A.M., E.M., . . . 1877
29 Broadway, New York City.
BUDELL, ALFRED E., C.E., ... 1904
Civil Eng., Westfield, N. J.
BUELL, THOS. RECTOR, E.M., ... 1905
Supt. in Gold Mt. District, Nevada.
BURBIDGE, THEODORE A., E.M., ... 1904
Sec. and Treas., Birmingham Car & Mfg. Co., Birmingham, Ala.
BURCH, JR., T. H., MECH.E., ... 1905
With Western Electric Co., New York City.
BURDEN, HENRY, 2d, A.B., PH.D., ... 1892
Pres., Cazenovia Electric Co. and Cazenovia Canning Co., Cazenovia, N. Y.
BURNS, ABRAHAM LINCOLN, E.M., ... 1887
Engineer, Jabez Burns & Sons, Mfrs. of Coffee and Spice Mill Machinery, New York City.
BURNS, ELMER Z., E.M., ... 1887
Mining Engineer, 159 Front Street, New York City.
BURNS, WM. G., E.E., ... 1898
With Jabez Burns & Sons, Mfrs. of Coffee and Spice Mill Machinery, New York City.
BUSSE, FRANZ A., C.E., ... 1903
Bridge Engineer, L. & N. R. R., Louisville, Ky.
BUTLER, WILLARD PARKER, E.M., LL.B., ... 1878
Lawyer, New York City.
CABOT, GEO. D., E.M., ... 1903
With Thompson Starrett Co., New York City.
CAETANI, DON GELASIO, C.E., E.M., ... 1903
Metallurgist, Bunker Hill & Sullivan M. & C. Co., Idaho.

Cairnes, Fred. I., Met.E., ... 1890
Supt., Michigan Smelting Co., Houghton, Mich.

Calman, Albert, Ph.B., Ph.D., ... 1882
Consulting Chemist, 42 East 23d Street, New York City.

Camp, Albert Roy, E.M., ... 1904
Pres., Camp Bros. Auto Touring Co., New York City.

Campbell, William, A.Sc., B.Sc., Ph.D., ... 1903
Instructor in Metallurgy, Columbia University, New York City.

Canfield, Frederick A., A.B., A.M., E.M., ... 1873
Mining Engineer, Dover, N. J.

Carleton, Robert A. W., C.E., ... 1904
Supt. of Constr. for R. F. Almirall, New York City.

Carpenter, H. C., E.E., ... 1899
Engineering Dept., N. Y. Telephone.

Carter, Alfred E., B.S., C.E., ... 1904
Asst. Eng., R. T. Subway Con. Co., New York City.

Casamajor, George H., C.E., ... 1892
Asst. Editor, Cosmopolitan Magazine, New York City.

Casey, Edward Pearce, C.E., Ph.B., ... 1886
Architect, New York City.

Catron, John W., E.M., ... 1904
Mining Engineer, Santa Fe, New Mexico.

Channing, John Parke, E.M., ... 1883
Pres., Tennessee Copper Co., and Consulting Engineer, New York City.

Chazel, P. E., Ph.B. (Chem.), ... 1881
Consulting Chemist, Broad Street, Charleston, S. C.

Chibas, Louis F., E.M., ... 1898
Civil Engineer, Gibara, Cuba.

Church, Elihu Cunyngham, C.E., ... 1904
Asst. Eng., R. R. Com., Washington.

Church, Elihu Dwight, Jr., E.M., ... 1887
Sec., Church & Dwight Co., New York City.

Church, John Adams, A.M., E.M., Ph.D., ... 1867
Consulting Mining Engineer, 15 William Street, New York City.

Church, John A., Jr., E.M., ... 1906
With Guanajuato Development Co., Mexico.

Churchill, Lewis T., C.E., ... 1905
Foreman for H. C. Van Emburgh, Civ. Eng., New Jersey.

Clark, Allan J., E.M., ... 1896
Assayer and Metallurgist, Homestake Mining Co., Lead, S. D.

Clark, Benjamin F., Jr., Mech.E., ... 1902
Chief Draftsman, Taylor Iron & Steel Co., High Bridge, N. J.

Clark, Carle Dawes, E.M., ... 1901
Supt., Metcalf Mine of Arizona Copper Co., Clifton, Ariz.

Clark, Charles Martin, E.E., ... 1897
Clark & MacMullen, Engineers, 20 Broad Street, New York City.
Clark, Edmund, M.S., ... 1892
Chemist, U. S. Dept. of Agriculture, New York City.
Clark, Edwin Perry, E. M., ... 1880
With Title Guarantee and Trust Co., Brooklyn, N. Y.
Clark, Franklin S., E.M., Ph.D., ... 1885
Pres. Georgia Pine Turpentine Co. of New York.
Clark, George Hallett, C.E., ... 1893
Senior Asst. Engineer, Rapid Transit Commission, New York City.
Clark, Walter Lemuel, Mech.E., ... 1901
Eng. for Francis Bros. & Jeelett, Consulting Eng., New York City.
Clarke, Robert W. M., Mech.E., ... 1902
With N. Y. Steam Fitting Co.
Close, Joseph Atwater, C.E., ... 1902
Asst. Engineer, Panama R. R., Panama.
Coelos, Jules Auguste, C.E., ... 1904
Sec. and Treas., Thomas J. Brady Co., Gen. Contractors, New York City.
Coffin, Tristram Robert, C.E., ... 1898
McKinnell, Coffin & Rawlins, Bonds, New York City.
Coggeshall, Allan C., E.E., ... 1903
Asst. Prof. Elect. Eng., Ohio State University.
Cokefair, Francis A., C.E., ... 1894
Chief Engineer, Great Northern Power Co., Duluth, Minn.
Colby, Albert Ladd, Ph.B., ... 1881
Consulting and Inspecting Engineer, New York City.
Collens, Clarence L. 2d, E.E., ... 1897
Asst. Supt., Canadian Niagara Power Co., Niagara Falls, N. Y.
Collins, Francis W., E.M., ... 1905
With H. P. Gillette, 11-21 Park Row, New York City.
Colton, Charles Adams, E.M., ... 1873
Director Newark Technical Schools, Newark, N. J.
Conant, Henry Dunning, E.M., ... 1886
Supt., Lake Superior Smelting Co., Dollar Bay, Mich.
Congdon, Ernest Arnold, Ph.B., F.C.S., ... 1887
Chemist, Board of Health, New York City.
Constant, Charles L., Jr., E.M., ... 1904
Mining Engineer, New York City.
Cook, Fredk. S., E.M., ... 1905
Consulting Engineer, Joplin, Mo.
Cook, Thomas F., Mech.E., ... 1904
Asst. Supt., Lackawanna Iron & Steel Co., Buffalo, N. Y.
Corbet, William W., Ph.B., E.M., ... 1904
Mining Engineer, Santa Fe, N. Mex.

CORNELL, MILTON LONGACRE, C.E., ... 1905
Engineer for J. B. & J. M. Cornell Co., New York City.

CORNWALL, HENRY BEDINGER, A.B., A.M., E.M., PH.D., . 1867
Professor of App. Chem. and Mineralogy, Princeton University.

COSGROVE, JOHN D., C.E., ... 1906
Engineer, with Hudson Companies, New York.

COX, JENNINGS STOKTON, JR., MET.E., ... 1887
Sec. and Treas., Ponupo Manganese Co., Santiago de Cuba.

COYKENDALL, EDWARD, C.E., ... 1895
Gen. Supt. U. & D. R. R., New York.

COYKENDALL, FREDK., A.B., A.M., C.E., ... 1897
Gen. Mgr., Cornell Steamboat Company, New York.

CRAMER, STUART W., E.M. (Associate), ... 1889
Contractor, Charlotte, N. C.

CRAMPTON, S. H., E.E., ... 1897
Asst. Supt. Eng., N. Y. Telephone Co.

CRAWFORD, H. E., E.M., ... 1899
Consulting Mining Engineer, New York City.

CREGIER, ABBOTT MICHEL, MECH.E., ... 1901
Engineer, Fibre Conduit Co., Orangeburg, N. Y.

CRISSEY, CLARENCE P., MECH.E., ... 1902
Asst. Eng., Steam Turbine Dept., Gen. Elect. Co., Lynn, Mass.

CROCKER, FRANCIS BACON, E.M., PH.D., ... 1882
Professor of Electrical Engineering Columbia University, New York City.

CROMWELL, ROBT. H., E.M., ... 1902
Supt., Minas Las Chiapas, Arizpe, Sonora, Mex.

CRUSER, FREDERICK V. D., B.S., ... 1903
Chemical Engineer, Union Metallic Cartridge Co., Bridgeport, Con.

CURRY, MALCOLM, MECH.E., ... 1903
Mech. Eng. of Willimantic Mills, Willimantic, Conn.

CURRY, ROBT., B.S. (Arch.), ... 1900
Architect, New York City.

DALY, EDWIN HOWELL, E.E., ... 1898
Engineer, Equipment Dept., New York Navy Yard.

DANIELS, HAROLD PLATT, E.E., ... 1902
Engineer, Peet & Powers, New York City.

DANZIGER, J. L., B.S. (Chem.), ... 1902
Assayer, International Ore Treating Co., New York City.

DAVIDSON, WILLIAM STEWART, E.M., ... 1897
Consulting Mining Engineer, New York City.

DAVIS, CHARLES HENRY, C.E., ... 1887
Consulting Engineer, 25 Broad Street, New York City.

de Coppet, T., B.S., ... 1897
Architect, New York City.

Deghuée, Joseph Albert, Ph.B. (Chem.), A.M., Ph.D., . 1890
V. Pres., Lederle Laboratories, New York City.

Delson, Isidore, C.E., ... 1899
Dept. of Bridges, New York City.

DeLuze, Louis Philippe,, C.E., ... 1879

Dempwolf, Chas. H., B.S. (Chem.), ... 1903
Chemist, York Chemical Works, York, Pa.

Denison, Griswold 2d, Mech.E., ... 1904
With P. R. Moses, Consulting Engineer, New York City.

Denton, Frederick Warner, C.E., ... 1889
Gen. Mgr., Copper Range Constr. Co., Michigan.

Derleth, Chas. Jr., B.S., C.E., ... 1896
Professor of Structural Engineering, University of California, Berkeley, Cal.

Derleth, Walter T., B.S., C.E., ... 1904
Engineer for D. J. Ryan, Contractor, Brooklyn, N. Y.

Detwiller, Chas. Henry, Ph.B. (Arch.), ... 1885
Architect, 99 Nassau Street, New York City.

Deutsch, Maurice, C.E., ... 1906
Asst. Eng., The Foundation Co., New York City.

Devereux, Walter Bourchier, A.B., A.M., E.M., . . 1878
Consulting Mining Engineer, 99 John Street, New York City.

Diamant, Sidney, E.E., ... 1902
Asst. Engineer, Dept. of Education, Building Bureau, New York City.

Dickerson, F. Secor, E.E., ... 1899
V. Pres., Glen Engineering Construction Co., New York City.

Dickie, Albert E., B.S. (Chem.), ... 1902
Instructor in Chem. in High School, Torrington, Conn.

Dickinson, Harold Thomas, E.M., ... 1900
Asst. Mgr., DeBeers Consolidated Mines, Kimberley, South Africa.

Dickson, Chas. W., Ph.D., ... 1903
Professor of Chemistry, School of Mines, Kingston, Ontario, Canada.

Dittenhoefer, L. F., Mech.E., ... 1903
Lawyer, New York City.

Dixon, James, E.E., ... 1901
Electrical Contractor, New York City.

Dodge, Francis Despard, Ph.D., Ph.B. (Chem.), . . . 1888
Manufacturing Chemist, New York City.

Donovan, Percy W., E.M., ... 1905
Supt. of Exploration for E. J. Longyear, Minnesota.

DOUD, CHARLES H., A.B., E.E., ... 1901
Manufacturing Stationer, New York City.

DOUGHERTY, RICHARD E., C.E., ... 1901
Civil Engineer, N. Y. C. & H. R. R. R.

DOUGHTY, J. B., C.E., ... 1906
Asst. Inspector, Bridge Dept., L. I. R. R., New York.

DOUGLAS, JOHN SHEAFE, C.E., ... 1890
Manufacturing Stationer, 22 Thames Street, New York City.

DOW, ALLAN WADE, PH.B., ... 1888
Consulting Chemist, New York City.

DOWNS, WILLIAM FLETCHER, E.M., ... 1882
Consulting Engineer, 75 Fairview Avenue, Jersey City, N. J.

*DRESSER, DANIEL LEROY, C.E., ... 1889

DRUMMOND, ISAAC WYMAN, E.M., PH.D., ... 1887
Chemist and Director, Devoe & Reynolds, New York City.

DUFOURCQ, EDWARD LEONCE, E.M., ... 1892
Consulting Mining Engineer, Produce Exchange Building, New York City.

DUNHAM, EDWARD KELLOGG, PH.B., ... 1881
Professor of Pathology in University and Bellevue Hospital Medical College, New York City.

DUNLOP, WM. C., MECH.E., ... 1906
Erecting Engineer, Allis Chalmers Co., New York City.

DUNN, GANO SILLECK, E.E., ... 1891
Vice-President, Crocker-Wheeler Co., Ampere, N. J.

DURHAM, EDWARD B., E.M., ... 1892
Chief Draftsman, Trenton Iron Co., Trenton, N. J.

DURHAM, H. W., C.E., ... 1895
Resident Engineer, Panama Water Works, Isthmian Canal Commission, Ancon Canal Zone.

DUSENBERRY, WALTER LAWTON, M.E., ... 1884
Eng. to Com. of Accts., New York City.

DWIGHT, ARTHUR SMITH, E.M., ... 1885
Gen. Mgr. Cananea Cons. Copper Co., Cananea, Sonora, Mex.

EARLE, ARTHUR WINTHROP, ... 1877
Winchester Repeating Arms Co., New Haven, Conn.

EBERHARDT, WILLIAM G., E.M., ... 1891
Mining Engineer, 450 West 22d Street, New York City.

ECKERSON, CHAS. H., E.M., ... 1898
Consulting Engineer, Englewood, N. J.

EDDINGFIELD, FRANK T., E.M., ... 1906
Supt., Emery Mine, Montana.

EDWARDS, RICHARD MASON, E.M., ... 1886
Agent, Franklin Min. Co., Houghton, Mich.

EILERS, KARL EMRICH, E.M., ... 1889
Director Am. S. & R. Co., New York City.

ELLIOTT, ARTHUR HENRY, PH.B., PH.D., ... 1881
Chem. Eng. to Con. Gas Co., New York City.

EMANUEL, L. V., E.M., ... 1896
Asst. Supt., Parting Plant, A. S. & R. Co., Perth Amboy, N. J.

ENGEL, LOUIS GEORGE, E.M., ... 1880
Engineer and Contractor, New York City.

ENGELHARDT, EUGENE NICHOLAS, E.M., ... 1885
Asst. Supt., Selby Smelting Co., Selby, Cal.

ENOS, HERBERT C., E.M., ... 1906
Mgr., Tehuantepec Silver Mine Co., San Geronimo, Mex.

EVANS, I. N., C.E., ... 1895
Consulting Engineer, 281 Water Street, New York City.

EVERETT, SAMUEL H., JR., E.E., ... 1903
With Gould Storage Battery Co., New York City.

FABER, JOHN PELHAM, MECH.E., ... 1903
Chief Draftsman, Ransome Concrete Machinery Co., New York City.

FALK, MYRON SAMUEL, C.E., PH.D., ... 1899
Consulting Engineer, 60 Wall Street, New York City.

FARMER, ALEXANDER S., C.E., ... 1897
Asst. Eng., Department of Water Supply, Gas and Electricity, New York City.

FEARN, PERCY LEROY, E.M., ... 1889
Consulting Engineer, 36 Wall Street, New York City.

FERGUSON, GEORGE ALBERT, PH.B., ... 1890
Chemist, State Board of Pharmacy, New York.

FERGUSON, WILLIAM C., PH.B., ... 1887
Consulting Chemist, Gen. Chem. Co., Laurel Hill, N. Y.

*FERRER, CARLOS FERRER, C.E., ... 1883

FEUST, ARTHUR, E.M., ... 1902
Eng. for I. O. T. Co., New York City.

FIES, MILTON H., E.M., ... 1904
Supt., Sayreton & Thompson Mines, Alabama.

FINCH, JAMES K., C.E., ... 1906
Inst. in R. R. Engineering & Surveying, Lafayette College.

FINLAY, GEO. I., A.B., PH.D., ... 1903
Professor of Geology, Colorado College, Colorado Springs, Colo.

FISHER, HENRY, B.S. (Chem.), ... 1899
Chemist, E. H. Cunningham & Co., Sugar Land, Tex.

Fisher, Willard, E.M., ... 1888
Agent, Illinois Zinc Co. & Star Engravers' Supply Co., New York City.

Fliess, Robert A., E.E., ... 1899
Pres., Combined Experimental & Mfg. Co., New Jersey.

Focardi, P. L., B.S., E.E., M.E., ... 1901
Chief Draftsman, N. J. F. & M. Co., New York City

Foote, Francis S., Jr., E.M., ... 1904
Asst. Eng., N. Y. C. & H. R. R. R., New York City.

Ford, Harry C., C.E., ... 1900
Engineer for Rodgers Contracting Co., New York City.

Ford, Walter H., C.E., ... 1903
City Surveyor, New York City.

Forst, Leo B. (Chem.), ... 1906
Asst. Chemist, Treasury Dept.

Foster, Pell W. (Associate), ... 1883
Pres., Power Specialty Co., 111 Broadway, New York City.

Foster, Reginald Guy, C.E., ... 1893
Structural Engineer, 29 Broadway, New York City.

Fowler, Samuel Stewart, A.B., E.M., ... 1884
Consulting Mining Engineer and Gen. Mgr., Canadian Metal Co., B. C.

Foyé, Andrew Ernest, C.E., ... 1890
Director, Parker, Ryan Construction, 21 Park Row, New York City.

Frank, Albert, E.M., ... 1905
Mining Engineer, Sombrerete Min. Co., Mexico.

Frank, Eugene, Mech.E., ... 1903
Contracting Engineer, 209 West 127th Street, New York City.

Frank, Jerome William, Ph.B., ... 1888
V. Pres., Ancrum Paper Mills, New York City.

Franklin, Milton W., E.M., ... 1906
Engineer, United Rico Mines Co., Rico, Colo.

Freedman, William Horatio, C.E., E.E., ... 1889
Professor of Electrical Engineering, University of Vermont.

Freund, Harry Paul, E.E., ... 1902
Contracting Engineer, 796 Lexington Avenue, New York City.

Freund, Mortimer, E.E., ... 1906
With Westinghouse Elect. Co., Pittsburg, Pa.

Fulton, Charles H., E.M., ... 1897
Consulting Mining Engineer and Pres., State School of Mines, Rapid City, South Dakota.

Fulton, J. A., E.M., ... 1900
Mining Engineer, Reno, Nevada.

GARCELON, CHARLES R., JR., C.E.,. 1902
Civil Engineer, North Lovell, Oxford County, Me.
GARLICHS, HERMAN, E.M., ... 1880
Supt., Perth Amboy Plant, A. S. & R. Co., Maurer, N. J.
GARTENSTEIG, CHARLES, B.S., C.E., ... 1895
Asst. Eng., Department of Highways, Borough of the Bronx, New York City.
GASTON, MELCHOR E., A.B., B.S., C.E., ... 1902
Consulting Engineer, Cardenas, Cuba.
GAY, FRAZER W., A.B., E.E., ... 1906
With Crocker-Wheeler Co., Ampère, New Jersey.
GIFFORD, STANLEY, E.M., ... 1889
Asst. Treas., Montana Ore Purchasing Co.; Sec. and Treas., Nipper Con. Copper Co. of Montana, and of United Copper Co., etc.
GILDERSLEEVE, ALGER C., C.E., ... 1890
Consulting Engineer, 215 West 125th Street, New York City.
GOEPEL, CARL P., E.E., LL.B., ... 1902
Attorney at Law and Patent Counsel, New York City.
GOETZE, FREDERICK A. (Associate), ... 1895
Dean, Faculty of Applied Science and Consulting Engineer, Columbia University.
GOING, CHARLES BUXTOM, PH.B., ... 1882
Editor, Engineering Magazine, New York City.
GOLDEN, PERCY NORRIS, E.E., ... 1902
Supt., Clerk Pub. Service Corp. of New Jersey.
GOLDMAN, M. I., E.M., ... 1905
Asst. Geologist, Am. Smelters Securities Co.
GOLDSCHMIDT, SAMUEL ANTHONY, A.B., A.M., E.M., PH.D., 1871
President, Columbia Chemical Works, 43 Sedgwick Street, Brooklyn, N. Y.
GOOD, GEORGE MCCLELLAN HOUTZ, E.M., ... 1886
Engineer, Coal Mining Cos., Osceola Mills, Pa.
GOODE, EDMUND L., E.M., ... 1901
With Atlantic & Cairo Constr. Co., 111 Broadway, New York City.
GOODMAN, LOUIS, C.E., ... 1903
Asst. Engineer, Bridge Dept., New York City.
GOODRICH, JOHN S., MECH.E., ... 1904
Draftsman, Trenton Iron Co., Trenton, N. J.
GOODWIN, EDWARD, E.M., ... 1891
Mining Engineer, San Francisco, Cal.
GOODWIN, H. H., C.E., ... 1906
Asst. Engineer, N. Y. Board of Water Supply.
*GORDON, JOHN, E.M., ... 1871
GOTTHELF, AUGUST H., B.S. (PH.D., 1900), ... 1897
Chemist, U. S. Pharmacopœia, Hastings-on-Hudson, New York.

*GOULD, EDWIN, ... 1888
195 Broadway, New York City.

GRACE, F. J. M., C.E., ... 1895
With W. R. Grace & Co., San Francisco, Cal.

GRAFF, CHARLES EVERITT, E.M., ... 1885
Supt., Eagle Works, Standard Oil Co., New Jersey.

GRANGER, A. D., C.E., ... 1892
Pres., Oswego Boiler Co., 95 Liberty Street, New York City.

GRANT, HARRY ALLEN, MECH.E., ... 1904
Mgr., Maxwell, Briscoe Motor Co., Tarrytown, N. Y.

GRANT, OLIVER R., E.E., ... 1902
Elect. Eng., The Safety Insulated Cable Co., New York City.

GRATACAP, LOUIS POPE, PH.B., A.M., ... 1876
Curator, American Museum Natural History, New York City.

GRAY, CLIFFORD, E.E., ... 1902
P. G. Student, Columbia University.

GREENE, DAVID JOY, C.E., M.E., ... 1894
Pres., Empire Wood Co., New Jersey.

GREENLEAF, JAMES LEAL, C.E., ... 1880
Landscape Architect, 1 Broadway, New York City.

GREVATT, F. F., E.E., ... 1903
With Crocker-Wheeler Co., Ampère, N. J.

GRISWOLD, CLYDE T., B.A., E.M., ... 1905
Asst. Supt., Canadian Copper Co., Ontario.

GUDEMAN, EDWARD, PH.B., PH.D., ... 1887
Consulting Chemist, 903-4 Postal Telegraph Building, Chicago, Ill.

GUDEWILL, CHARLES EDWARD, C.E., ... 1890
Engineer, Montreal Pipe Foundry, Ltd., Canada.

GUITERMAN, EDWARD WOLF, PH.B., ... 1889
Supt., Passaic Print Works, N. J.

GUNTHER, C. GODFREY, E.M., ... 1903
Mining Engineer, Clifton, Ariz.

HAAS, EDWARD F., B.S., C.E., ... 1894
Sanitary Engineer, San Francisco, Cal.

HAAS, HENRY C., E.E., ... 1905
With Electric Storage Battery Co., New York City.

HAASIS, DUNBAR FERDINAND, E.M., ... 1883
Engineer, R. & H. Improvement, Atlantic Coast.

HAFFEN, LOUIS FRANCIS, A.M., C.E., ... 1879
President, Borough of Bronx, New York City.

HAHN, ALBERT W., B.S. (Chem.), ... 1905
Chemist for O. y T. Braniff, Mexico.

HAIGHT, LOUIS H., E.E., ... 1904
With Westinghouse Elec. & Mfg. Co., New York City.

HAIGHT, CLARENCE M., E.M., ... 1906
Mining Engineer, Adventure Con. Copper Co., Michigan.

HAINES, HAROLD W., B.S. (Chem.), ... 1903
Instructor Physics, High School of Commerce, New York City.

HALL, ROBERT WILLIAM, E.M., ... 1876
Professor of Chemistry, N. Y. University.

HALLOCK, ALBERT PETER, PH.B., PH.D., ... 1880
Chemist, Carl H. Schultz Mineral Water Co., 440 First Avenue, New York City.

HAMILTON, FRANK C., E.M., A.M., ... 1894
Mining Engineer, Minera de Penoles, Mapimi, Mexico.

HARDING, GEORGE EDWARD, ... 1867
Architect, 253 Broadway, New York City.

HARRINGTON, THOMAS HENRY, C.E., ... 1889
Tutor in Drawing, Columbia University, New York City.

HART, CHAS. H., C.E., ... 1900
Public Accountant, 199 Lenox Avenue, New York City.

HARWOOD, PAUL H., E.M., ... 1903
Asst. Mgr., Mexican Asphalt Paving Co., Mexico.

HASKELL, G. M., E.E., ... 1898
Electrician, The Safety Insulated Wire & Cable Company, New York City.

HASKELL, HARRY GARNER, E.M., ... 1893
Sec., Repauno Chemical Company, & Hercules Powder Company, Delaware.

HATCH, WALTER P., JR., MECH.E., ... 1902
Asst. Mgr., Continental Car & Equipment Co., New York City.

HATHAWAY, NATHANIEL, PH.B., ... 1879
Professor of Chemistry, Swain Free School, New Bedford, Mass.

HAVILAND, HENRY FIELD, E.E., ... 1902
Elect. Eng., Francis Bros. & Jellett, Inc., Engineers and Contractors, New York City.

HAVILL, OWEN A., A.B., E.E., ... 1901
In office of Viele-Cooper & Blackwell, Consulting Engineers, New York City.

HAWKESWORTH, JOHN, C.E., ... 1904
Asst. Eng. with R. F. Almirall, Architect, New York City.

HAWLEY, JOHN FRANCIS, C.E., ... 1891
Engineer, Guatemala, Central America.

HAY, ARTHUR, E.M., ... 1892
Engineer of Park Destr., Springfield, Ill.

HÉBERT, OCTAVE BRITTON, C.E., ... 1888
Sec. and Treas., Aitken Construction Co., New York City.

HEINSHEIMER, ALFRED MORRIS, C.E., ... 1887
Tractel Marble Co., 133 West 42d Street, New York City.

HEINZE, F. AUGUSTUS, E.M., ... 1889
31 Nassau Street, New York City.

HELLER, CLARENCE, C.E., ... 1904
Consulting Engineer, San Francisco, Cal.

HENDRICKSON, W. H., E.M., ... 1903
Engineer, Germini & Godiva Min. Cos., Utah.

HENES, LOUIS GEORGE, MECH.E., ... 1903
Mgr., Machine Tool Dept. of Harron, Rackard & McCone, San Francisco, Cal.

HERZIG, C. S., E.M., ... 1895
Engineer for Bewick, Moering & Co., London, England.

HEWLETT, JAMES MONROE, PH.B., ... 1890
Architect, 16 East 23d Street, New York City.

HIGBIE, H. HAROLD, E.E., ... 1904
Instr. in Elect. Eng., University of Michigan.

HILDRETH, WALTER EDWARDS, C.E., E.M., ... 1877
Consulting Engineer, 115 Broadway, New York City.

HILL, WILLIAM, C.E., ... 1882
Pres., Collins Company, Collinsville, Conn.

HINMAN, BERTRAND CHASE, PH.B., A.M. (1892), . . 1890
Director, Central Chili Copper Co., etc., 48 Sydenham Hill, S. E. London, England.

HIRSCHTHAL, MEYER, B.S., C.E., ... 1902
With Henry Steers, Inc., New York City.

HITCHCOCK, C. K., JR., A.B., A.M., E.M., ... 1900
Chief Eng. Quincy Mine, Hancock, Mich.

HOCHLERNER, TOBIAS, C.E., ... 1901
Asst. Eng., Aqueduct Co., New York.

HOCHSPRUNG, GEORGE W., E.E., ... 1904
With N. Y. & N. J. Telephone Co., New York City.

HOGUET, RAMSAY, E.E., ... 1903
Contractor, 141st Street and Hudson River, New York City.

HOLDEN, CHARLES A., C.E., ... 1903
Asst. Eng., Penn., N. Y. & L. I. R. R.

HOLDEN, EDWIN C., B.S., E.M., ... 1896
Consulting Engineer, 74 Wall Street, New York City.

HOLDEN, EDWARD HENRY, C.E., ... 1878
Engineer, Board of Public Improvements, New York City.

HOLLICK, ARTHUR, PH.B., PH.D., ... 1879
Curator, Botanical Gardens, New York City.

HOLLIS, HENRY LEONARD, E.M., ... 1885
Consulting Mining Eng. and Metallurgist, First National Bank Building, Chicago, Ill.

HOLLIS, WILLIAM, C.E., ... 1878
Civil Engineer, Eagle Pass, Tex.

HOLLMAN, F. W., MECH.E., ... 1905
Steam Engineer, Maryland Steel Co.

HOLT, MARMADUKE BURRELL, E.M., ... 1889
Mining Engineer, Silverton, Colo.

HOOPER, FRANK CYRUS, MET.E., ... 1890
Consulting Mining Engineer, North River, Warren Co., N. Y.

HOOPER, GEO. H., JR., E.E., ... 1905
With Edison Storage Battery Co., New Jersey.

HOPKINS, GEO., A.B., MECH.E., ... 1901
Inspector, N. Y. Board of Fire Underwriters, New York City.

HORNE, WILLIAM DODGE, PH.B. (Chem.), PH.D., . . 1886
Consulting Chemist, Yonkers, N. Y.

HOSFORD, LEONARD P., C.E., ... 1906
Sec., Spalding-Hosford Co., Inc., New York City.

HOWE, EPENETUS, E.M., ... 1886
Consulting Engineer, Monterey, Mex.

HOWELL, JOHN JACOB, MECH.E., ... 1904
With A. B. See Elevator Co., New York City.

HOYT, J. R., E.M., ... 1906
Mine Examinations in Canada.

HUDSON, P. K., E.M., ... 1899
Partner, C. I. Hudson & Co., New York City.

HULBERT, CHARLES S., E.E., ... 1899
With Gen. Elec. Co., Lynn, Mass.

HULBERT, WILLIAM R., MECH.E., ... 1904
Managing Editor, "Compressed Air," New York City.

HUMPHREY, F. L., C.E., ... 1905
Engineering Aid, U. S. Reclamation Service.

HUNT, FREDERICK FURNEAUX, E.M., C.E., ... 1876
C. W. Hunt Co., Coal Handling Machinery, 45 Broadway, New York City.

HUNTINGTON, F. W., E.M., ... 1885
Professor of Physics, H. S., Brooklyn, N. Y.

HUNTOON, L. D., E. M., PH.G., ... 1895
Professor of Mining & Metallurgy, Sheffield Scientific School, Yale University.

HUTTON, FREDERICK REMSEN, A.B., A.M., E.M., C.E., PH.D., Sc.D., ... 1876
Emeritus Professor of Mechanical Engineering, Columbia University.

HYDE, FREDERICK S., PH.B., ... 1893
With Dr. H. N. Potter, New York City.

HYDE, HENRY ST. JOHN, B.S. (Chem.), PH.B., A.M., . . 1896
P. G. Student, Columbia University.

HYMAN, WALLACE M., E.E., ... 1902
With P. R. Moses, Consulting Engineer, 320 Fifth Avenue, New York City.

IHLSENG, M. C., C.E., PH.D., ... 1875
Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, New York City.

*ILES, MALVERN WELLS, PH.B. (Chem.), PH.D., . . . 1875
Southwestern National Bank, Los Angeles, Cal.

IMMEDIATO, GERARDO, MECH.E., C.E., ... 1901
Asst. Eng., Monterey Water Works, Monterey, Mex.

INGRAM, EDWARD LOVERING, C.E.,. 1885
Asst. Prof. of Civil Engineering, University of Pennsylvania.

IRVINE, FREDERICK BRICE, C.E., ... 1902
Consulting Engineer, 25 Broad St., New York City.

IRVING, JOHN DUER, A.M., PH.D., ... 1899
Professor of Economic Geology, S.S.S., Yale University.

JACKSON, OSWALD, C.E., ... 1892
Inspector, Dept. Highways, New York City.

JACOBS, DAVID MARK, PH.B., ... 1887
Manufacturer, 41 New Street, New York City.

JACOBS, SOLOMON JOSEPH, PH.B., ... 1887
Manufacturer, 41 New Street, New York City.

JACOBY, HENRY E., MECH.E., ... 1903
Manager, Marcus Mason & Co., New York City.

JAMES, MARSHALL T., B.S. (Arch.), ... 1900
Architect, New York City.

JANEWAY, JOHN HOWELL, E.M., ... 1886
Gen. Mgr., Mineral Point Zinc Co., Chicago, Ill.

JARCHO, ISAIAH, E.E., ... 1904
With N. Y. C. & H. R. R. R. Co., New York City.

JARMAN, Z. H., E.M., ... 1895
Real Estate, Los Angeles, Cal.

JENKS, ARTHUR WILTON, E.M., ... 1886
Gen. Mgr., White Knob Copper Co., Idaho.

JOBBINS, F. H., PH.B., ... 1895
Sec.-Treas., Wm. F. Jobbins Incorporated, Aurora, Ill.

JOHNSON, ARTHUR GALE, E.M., ... 1885
Member of firm, Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, A. M., E.M., ... 1906
Surveyor, New Jersey Zinc Co., N. J.

JOHNSON, ELIAS MATTISON, PH.B. (Chem.), . . . 1878
Pres., Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, GILBERT HENRY, PH.B. (Chem.), ... 1878
Member of firm, Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, ISAAC BRADLEY, E.M., ... 1879
Member of firm, Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, ROBERT McL., E.M., ... 1906
Asst. Eng., Spanish Amer. Iron Co., Cuba.

JOHNSTONE, WILLIAM BAIRD, C.E., ... 1895
Asst. Engineer, P., N. Y. & L. I. R. R.

JONES, J. ELMER, E.M., ... 1893
Supt., Mill Creek Coal Co., Hazleton, Pa.

JOPLING, REGINALD FURNESS, E.M., ... 1889
Consulting Engineer, Cuyahoga Building, Cleveland, O.

JOSEPH, THEO. H., E.E., ... 1898
Contracting Engineer, New York City.

JOSEPHI, ROBERT, E.E., ... 1906
Chemical Importer, New York City.

JOSEPHSON, EDGAR, B.S. (Chem.), ... 1900
Chemist, Potasote Leather Co., New Jersey.

JOÜET, CAVALIER HARGRAVE, PH.B., PH.D., ... 1882
Tutor in Anal. Chem., Columbia University, New York City.

JUDSON, HANFORD C., E.E., ... 1898
Engineer with G. E. Co., New York City.

JULIHN, CARL EDWARD, E.M., ... 1904
Mining Engineer, Helena, Mont.

KAPLAN, HARRY, B.S., MECH.E., A.M., ... 1906
Asst. Eng., Struct. Mats., Test Lab., U. S. Geol. Survey.

KAUFMAN, ALFONSE, E.E., ... 1906
With Westinghouse Mfg. Co., Pittsburg, Pa.

KAYSER, WILLIAM D., MECH.E., ... 1903
Draftsman, Standard Plunger Elev. Co., New York City.

KELLOGG, J. BLAKE, MECH.E., ... 1904
With Sanderson & Porter, New York City.

KELLOGG, L. O., E.M., ... 1906
Engineer, Amer. Reviera Min. Co., Mexico.

KEMP, JAMES FURMAN, A.B., E.M., ... 1884
Professor of Geology, Columbia University, New York City.

KERN, EDWARD F., B.S., PH.D., ... 1901
Tutor in Metallurgy, Columbia University.

KINSEY, FRANK WILMARTH, C.E., ... 1891
Supt., Morris & Cummings Dredging Co., New York City.

KING, CHAS. A., MECH.E., ... 1906
With H. E. Meyer, Jr., Consulting Eng., New York City.

KIPP, BURDETT, C.E., ... 1898
Asst. Engineer, R. T. Com., New York City.

KIRBY, G. T., E.E., LL.B., ... 1895
Lawyer.

KISSAM, H. S., PH.B., ... 1886
Architect, New York City.

KLEPETKO, FRANK, E.M., ... 1880
Consulting Engineer, 304 Battery Park Building, New York City.

KNIFFEN, LLOYD M., E.M., ... 1906
Cyanide Supt., Dolores Mines Co., Mexico.

KNOBLAUCH, GEO. W., E.M., ... 1903
Min. Eng., Central Chili Copper Co., Coquimbo, Chili.

KNOX, CHAS. E., E.E., ... 1892
Consulting Engineer with C. Q. Mailloux, 76 William Street, New York City.

KOHLER, L. FRANK, C.E., ... 1906
Inspector, N. Y. C. & H. R. R. R. Co.

KOHNSTAMM, LOTHAIR S., B.S. (Chem.), ... 1902
Chemist and Supt., Atlas Color Factory, New York City.

KORN, LEWIS, PH.B. (Arch.), ... 1890
Architect, 261 Broadway, New York City.

KRAEMER, HENRY, PH.B. (Chem.), ... 1895
Consulting Chemist, 145 North 10th Street, Philadelphia.

KRUMB, HENRY, E.M., ... 1898
Engineer with Guggenheim Exp. Co., 1103 Braly Building, Los Angeles, Cal.

KUNHARDT, WHEATON BRADISH, E.M., ... 1880
Gen. Mgr. Carpenter Steel Co., Reading, Pa.

KURTZ, EDWARD LAURENCE, E.M., ... 1893
Instructor in Mining, Columbia University.

LACOMBE, CHARLES FREDERICK, E.M., ... 1885
Engineer, Dept. Water Supply, Gas, etc., New York City.

LADEW, J. HARVEY, ... 1885
Consulting Chemist, 300 Central Park West, New York City.

LAHEY, RICHARD, E.M., ... 1887
Contracting Engineer, Ford, Kentucky.

LAMB, ANDREW JOHNSON, E.M., ... 1884
Roadmaster, L. & N. R. R., Nashville, Tenn.

LAMME, MAURICE A., B.S., A.M., ... 1904
Asst. in Mineralogy, Columbia University.

LANDERS, W. H., E.M., ... 1903
Mining Engineer, San Francisco, Cal.

LANGMUIR, IRVING, MET.E.., ... 1903
Instructor in Engineering Chemistry, Stevens Inst., New Jersey.

LANGTHORN, JACOB S., ... 1891
Div. Eng., Board of Water Supply, New York City.

LAUGHLIN, W. C., E.M., ... 1899
Smelter, Safford, Ariz.

LAURIE, HAROLD N., E.M., ... 1905
Engineer, Greenback Gold Min. Co., Oregon.

LAW, CHARLES T., E.M., ... 1903
Chief Engineer, Deep Gravel Min. Co., Kougarok, Alaska.

LAWRENCE, BENJAMIN BOWDEN, E.M., ... 1878
Consulting Engineer, 56 Wall Street, New York City.

LAZINISK, A., C.E., ... 1905
Bridge Draftsman, Erie R. R., Buffalo, N. Y.

LEARY, DANIEL JAMES, C.E., E.M., ... 1881
Engineer and Contractor, 26 West 49th Street, New York City.

LEARY, GEORGE, C.E., ... 1891
Pres., Morris & Cummings Dredging Co., 17 State Street, New York City.

LEBOUTILLIER, CLEMENT, PH.B., ... 1881
Chemist, Taylor Iron & Steel Co., High Bridge, N. J.

LEDERLE, ERNST JOSEPH, PH.B., PH.D., ... 1886
Consulting Chemist, 518 Fifth Avenue, New York City.

LEDOUX, ALBERT REID, M.S., PH.D., ... 1874
Consulting Engineer and Chemist, New York City.

LEE, GEORGE BARSTOW, E.M., ... 1885
Supt., Copper Queen Smelter, Douglas, Ariz.

LEGETT, THOMAS HAIGHT, E.M., ... 1879
Consulting Engineer, 688-689 Salisbury House, London Wall, London, E. C., England.

LENOX, LIONEL REMOND, PH.B., ... 1888
Professor of Anal. Chem., Stanford University, Palo Alto, Cal.

LE PRINCE, JOSEPH A., C.E., A.M., ... 1898
R'way Engineer, West Virginia.

LEVINE, ALBERT JULIUS, E.E., ... 1901
Manufacturer, New York City.

LEVINE, EDMUND, J., B.S., ... 1898
Chemist, Fiberloid Company, 636 Broadway, New York City.

LEVITT, B. A., C.E., ... 1903
Asst. Eng. Board of Water Supply, New York City.

LEWINSON, LEONARD JULIAN, E.E., ... 1904
Electrical Engineer, 129 East 95th Street, New York City.

LEWIS, CLARENCE MCKENZIE, C.E., ... 1898
Banker, 25 Broad Street, New York City.

LEWIS, MEYER H., C.E., ... 1900
Asst. Engineer on Croton Aqueduct, New York.

LIBAIRE, EDWARD W., C.E., ... 1894
Engineer to Finance Dept., New York City.

LICHTENBERG, J. CHESTER, E.E., ... 1906
Asst. to Professor Pupin, Columbia University.

LIDGERWOOD, JOHN HEDGES, M.E., E.M., ... 1901
Lidgerwood Mfg. Co., New York City.

LIEBMANN, ALFRED, C.E., ... 1893
Brewer, New York City.

LIGHTHIPE, WILLIAM WILSON, E.E., ... 1898
Engineer, Otis Elevator Co., New York City.

LILLARD, OGDEN W., E.E., ... 1903
Engineer, N. Y. Navy Yard.

LILLIE, SAMUEL MORRIS, E.M., ... 1874
Pres., Sugar App. Mfg. Co., 328 Chestnut Street, Philadelphia, Pa.

LILLIENDAHL, ALFRED WHIPPLE, E.M., ... 1883
Pres. and Gen. Mgr., Coahuila & Pacific R. R. Co., Saltillo, Coahuila, Mex.

LILLIENDAHL, FRANK ARMSTRONG, E.M., ... 1891
Mgr., Coahuila & Pac. R. R., Saltillo, Coahuila, Mex.

LINDEMAN, MAURICE, B.S. (Chem.), ... 1903
Metallurgist, DeLamar Gold Mines, Nevada.

LINDSAY, WM. G., B.S. (Chem.), ... 1901
Chemist for Ricketts & Banks, New York City.

LIPPS, HENRY, JR., C.E., ... 1888
Contracting Engineer, 115 Elliott Avenue, Williamsbridge, New York City.

LIVINGSTON, ARCHIBALD ROGERS, C.E., ... 1891
Engineer, Empire Zinc Co., Cañon City, Colo.

LIVINGSTONE, JOHNSTONE, JR., E.E., ... 1898
Electrical Engineer and Contractor, 113 East 22d Street, New York City.

LODER, ELWOOD H., C.E., ... 1903
Asst. Eng., Tompkins Engineering & Constr. Co., New York City.

LOEWENTHAL, MAX, E.E., ... 1897
Pres., International Elec. & Eng. Co., 39 Cortlandt Street, New York City.

LONGACRE, LINDSAY B., E.M., B.D., ... 1892
Clergyman, Spuyten Duyvil, N. Y.

LORD, FREDERICK REUBEN, C.E., ... 1892
Coal Broker, 25 Broad Street, New York City.

LOVE, EDWARD GURLEY, A.M., PH.B., PH.D., ... 1876
Chief Gas Examiner, New York City.

LOVEMAN, HERBERT S., MECH.E., ... 1905
With Henry R. Worthington, Hydraulic Works, Newark, N. J.

LOWTHER, C. M., E.E., ... 1898
Real Estate Broker, New York City.

LUCAS, R. J., C.E., ... 1905
Topographical Draftsman, Borough of Bronx, New York City.
LUCKE, CHAS. E., B.S., M.S., PH.D., ... 1901
Adj. Professor, Mech. Eng., Columbia University.
LUDLAM, WM. K., C.E., ... 1901
Banker, 25 Broad Street, New York City.
LUDLOW, EDWIN, E.M., ... 1879
Mgr., Mexican Coal & Coke Co., Les Esperanzas, Coahuila, Mex.
LUNT, HORACE F., E.M., ... 1902
Mining Engineer, Colorado Springs, Colo.
LUQUER, LEA McILVAINE, C.E., PH.D. (1894), . . . 1887
Adj. Professor of Mineralogy, Columbia University, New York City.
LUQUER, THATCHER TAYLOR PAYNE, C.E., E.E. (1892), . . 1889
Consulting Engineer, 5 West 31st Street, New York City.
LUSK, GRAHAM, PH.B., PH.D., M.A., F.R.S., ... 1887
Professor of Physiology, N. Y. University and Bellevue Hospital College, New York City.
LUTHER, EDWIN C., C.E., E.M., ... 1904
Engineer, Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.
LYDECKER, IRVING SMITH, E.M., ... 1898
Supt., Seaboard Coal & Coke Co., Alabama.
LYMAN, FRANK, A.B., E.M., ... 1878
Treasurer, The Low Min. Iron Co., Virginia, 88 Wall Street, New York City.
LYON, GEORGE JOHN, B.S., C.E., ... 1904
Professor of Civil Engineering, Colorado College, Colorado Springs, Colo.
McCAFFERY, R. S., E.M., ... 1896
Mgr., Salt Lake Copper Co., Utah.
McCASKELL, JASPER A., E.M., ... 1903
Supt., Daly West Mine, Park City, Utah.
McCLAIN, H. G., E.M., ... 1906
Engineer, Liberty Bell Gold Min. Co., Colorado.
McCLELLAND, JAMES F., E.M., ... 1900
Gen. Mgr., So. Nevada Co., Nevada.
McCONWAY, WILLIAM, JR., E.M., ... 1896
Supt., McConway & Torley Co., Pittsburg, Pa.
McDOWELL, W. ST. L., C.E., ... 1903
Transitman, Int. R. R., Mexico.
McILHINEY, PARKER C., A.M., PH.D., ... 1892
Consulting Chemist, 145 East 23d Street, New York City.
McINTYRE, HENRY K., E.E., ... 1899
Engineering Dept., N. Y. Telephone Co., New York.

McKim, Alex. Rice, B.S., A.M., ... 1897
Architect, 36 East 28th Street, New York City.

McKim, Robert Albert, C.E., ... 1884
Consulting Civil Engineer, 34 West 91st Street, New York City.

McKinlay, Wm. Bradford, E.M., ... 1895
Mining Engineer, Newhouse, Utah.

McKinney, F. W., C.E., ... 1906
Engineer, LaDicha & Pacific R. R. Co.

McLaughlin, Cyril B., B.S. (Chem.), ... 1903
Chemist, 254 West 136th Street, New York City.

McLoughlin, Charles Swain, Ph.B. (Chem.), . . . 1884
Publisher, 890 Broadway, New York City.

MacDougall, C. W., E.M., ... 1903
Chief Eng., Hancock Consolidated Mining Co., Michigan.

MacMullen, Charles W., E.E., ... 1897
Consulting Engineer, New York City.

Machen, Charles Hudson, E.E., ... 1899
Treas., Georgetown Light, Heat & Power Co., Philadelphia, Pa.

Machen, Henry B., C.E., ... 1898
Engineer, Dept. Water Supply, New York City.

MacKaye, Harold Steele, C.E., ... 1887
Lawyer, 29 Liberty Street, New York City.

Maclay, James, C.E., Ph.D., ... 1888
Professor of Mathematics, Columbia University, New York City.

Maeulen, Frederick, E.M., ... 1902
Maeulen & Wilson, Pyrometers, New York City.

Magnus, Benjamin, E.E., ... 1900
Consulting Metallurgical Engineer, New York City.

Maisenholder, Edward F., C.E., ... 1903
Topographical Draftsman, New York City.

Malcolmson, A. S., C.E., ... 1905
Engineering Corps, R. R. Com., Washington, D. C.

Malukoff, Alexis J., C. E., ... 1893
Asst. Eng., Dept. of Bridges, New York City.

Mannheim, Hermann Charles, E.M., ... 1887
Consulting Engineer, 26 Finsbury Square, London, E. C., England.

Mannheim, Paul August Louis, E.M., ... 1885
Metallurgist, A. S. & R. Co., Maurer, N. J.

Mapes, Charles M., C.E., ... 1902
Civil Engineer, Third Avenue and 148th Street, New York City.

Marble, Ralph N., Jr., E. M., ... 1905
Asst. Eng., Olim Iron Min. Co., Minn.

*Marie, Leon, E.M., ... 1885

Marsten, Charles S., Mech.E., ... 1902

Martin, Franklin, Mech.E., ... 1904
1600 Hamilton Street, Philadelphia, Pa., and West Orange, N. J.

Martin, L. Trowbridge, E.E., ... 1898
56 West 33d Street, New York City.

Massa, Charles Griswold, C.E., ... 1889
Consulting Civil Engineer, 84 Warren Street, New York City.

Masters, Harris K., E.M., ... 1894
Supt., Central Chili Copper Co., Coquimbo, Chili.

Mathews, John Alexander, B.S., M.S., A.M., Ph.D., . . 1895
Metallurgist for Crucible Steel Co. of America, Syracuse, N. Y.

Matthews Chas. E., C.E., ... 1905
Asst. Eng., Belmont Tunnel, N. Y. & L. I. R. R. Co.

Matty, Leo Joseph, Mech.E., ... 1903
Attorney at Law and Patent Counsel, 141 Broadway, New York City.

Mayer, Lucius W., E.M., ... 1904
Engineer, Federal Lead Co., Flat River, Mo.

Mayer, Ralph Edward, C.E., ... 1879
Adj. Professor of Engineering Drafting, Columbia University, New York City.

Meehan, John A. Mech.E., ... 1901
With Sanderson & Porter, 52 William Street, New York City.

Meeks, Reginald, Mech. Eng., ... 1902
Mechanical Engineer, Jackson Building, Chicago, Ill.

Meikleham, T. M. R., C.E., ... 1890
Consulting Engineer, 44 Broad Street, New York City.

Meissner, Carl August, Ph.B., ... 1880
Asst. to Pres., U. S. Steel Corporation, New York City.

Melliss, D. Ernest, A.M., Ph.D. (Associate), . . . 1868
Consulting Engineer, San Francisco, Cal.

Menges, Charles P., E.E., ... 1904
Chemist to N. Y. Edison Co.

Menges, Phillip C., E.E., ... 1902
Engineer with J. Livingston, Jr., & Co., New York City.

Menline, Isaac, C.E., ... 1898
With Snare & Frieste.

Merrill, Frederick James Hamilton, Ph.B. (Geol.), Ph.D., 1885
Consulting Geologist, 20 East 42d Street, New York City.

Merritt, James Haviland, Ph.B., A.M., ... 1880
Architect, 40 Court Street, Brooklyn, N. Y.

Merry, Fredk. Chas., E.M., ... 1902
Engineer, Ferguson Mines, Ltd., B. C.

MERSEREAU, GAIL, B.S. (Chem.), ... 1903
Chemist, 105 East 17th Street, New York City.
MERZ, EUGENE, B.S., E.M., ... 1891
Pres., Ultramarine Co., Newark, N. J.
MESEROLE, WALTER MONTFFORT, C.E., ... 1881
Civil Engineer, 44 Court Street, Brooklyn, N. Y.
MESSITER, E. H., C.E., ... 1894
Engineer, Robins Conveying Belt Co., Park Row Building, New York City.
METTLER, ARTHUR J. (Chem.), ... 1905
Chemist, Fibre Conduit Co., Orangeburg, N. Y.
MEYER, HERMAN HENRY BERNARD, E.M., ... 1885
Chief Periodical Div., Congressional Library, Washington, D. C.
MIDDLETON, JOHN, C.E., ... 1887
City Surveyor, 2505 Atlantic Avenue, Brooklyn, N. Y.
MILES, GEORGE FREDERICK, C.E., ... 1904
With N. Y. C. & H. R. R. R. Co., The Chelsea, West 23d Street, New York City.
MILLER, CHARLES LEWIS, E.M., ... 1882
Gen. Supt., Am. Steel & Wire Co., Pittsburg, Pa.
MILLER, CHARLES WATTS, E.M., ... 1884
Asst. Mgr., Bagdad Chase Gold Min. Co., California.
MILLER, RUDOLPH PHILLIP, C.E., ... 1888
Consulting Engineer, 527 Fifth Avenue, New York City.
MILLER, SAMUEL O., C.E., ... 1895
Tutor in Drawing, Columbia University, and Consulting Engineer, New York City.
MILLS, RONALD VAN C., E.M., ... 1906
Chemist, San Pedro Mines, N. Mex.
MITCHELL, HENRY BEDINGER, E.E., A.M., ... 1898
Adj. Prof. in Mathematics, Columbia University, New York City.
MOELLER, EDGAR J., PH.B. (Chem.), ... 1895
Architect, 7 West 38th Street, New York City.
MOFFATT, MILES R., B.S., ... 1901
Instr. in Chemistry, Lowell Textile School, Lowell, Mass.
MOLDENKE, RICHARD GEORGE GOTTLOB, E.M., PH.D., . . 1885
Consulting Metallurgist, Watchung, Somerset Co., N. J.
MONELL, AMBROSE, E.E., ... 1896
President, International Nickel Company, New York City.
MONELL, JOSEPH THOMPSON, C.E., ... 1889
Engineer, Alphaduct Mfg. Co., New York City.
MONKS, RICHARD A., ... 1894
Contracting Engineer, 82 Beaver Street, New York City.
MORA, MARIANO LUIS, C.E., ... 1891
Foreign Dept., G. E. Co., 44 Broad Street, New York City.

MORAN, DANIEL EDWARD, C.E., ... 1884
Vice-President, The Foundation Co., 35 Nassau Street, New York City.

MORGAN, J. A., E.E., A.M., ... 1902
With Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

MORGAN, WILLIAM FELLOWES, A.B., E.M. (Life Member), . 1884
Pres., Harrison Cold Storage Co., Arch 5, Brooklyn Bridge, New York City.

MORLEY, FREDK. H., A.B., E.M., ... 1902
Consulting Mining Engineer, Denver, Colo.

MORLEY, WM. R., E.M., ... 1902
Mining Engineer, Datel, Socorro Co., New Mexico.

MORRILL, WM. CHARLES, E.E., ... 1899
Sec.-Treas., The Nightingale Co., New York City.

MORRISON, CHARLES E., C.E., A.M., ... 1901
Asst. in Civil Engineering, Columbia University, New York City.

MOSES, ALFRED JOSEPH, E.M., PH.D., ... 1882
Professor of Mineralogy, Columbia University, New York City.

MOSES, PERCIVAL ROBERT, E.E., ... 1895
Consulting Engineer, 320 Fifth Avenue, New York City.

MOSLEY, RICHARD KEELER, PH.B., ... 1889
Architect, 1 Nassau Street, New York City.

MULFORD, ROBERT, E.M., ... 1884
Engineer, Allis-Chalmers Co., 71 Broadway, New York City.

MULLER, GEO., PH.B. (Chem.), ... 1887
Chemist, Hoboken, N. J.

MULLER, JULIUS, E.E., ... 1899
Electrical Eng., United Electric Co., New Jersey.

MULLIKEN, HARRY B., PH.B., ... 1895
Architect, 7 West 38th Street, New York City.

MUNROE, HENRY SMITH, E.M., PH.D., DR.S., . . . 1869
Professor of Mining, Columbia University, New York City.

MUNROE, OTIS MORTIMER, PH.B. (Chem.), ... 1879
Banker, De Soto, Mo.

MUNSELL, CHARLES EDWARD, PH.B. (Chem.), PH.D., . . 1878
Chemist for F. W. Devoe & C. J. Raynolds, New York City.

MURPHY, J. LEO, C.E., ... 1904
Asst. Eng., Board of Water Supply, New York City.

MURPHY, WM. A., C.E., ... 1902
Treasurer, J. D. Murphy Co., 1181 Broadway, New York City.

MYERS, DAVID MOFFAT, MECH.E., ... 1901
Consulting Engineer, New York City.

NAVARRO, JOHN ADALBERT, C.E., ... 1880
Gen. Mgr., Cordola & Huatusco Railroad, Mexico.

Nesmith, James E., E.M., ... 1879
Merchant, 256 Henry Street, Brooklyn, N. Y.
Neu, S. Sidney, E.E., ... 1901
Crocker-Wheeler Co., Ampère, N. J.
Newbrough, William, A.B., E.M., ... 1884
Consulting Engineer, Evanston, Wyo.
Newhouse, Edgar L., E.M., ... 1886
Eng., A. S. & R. Co., 71 Broadway, New York City.
Nichols, Ralph, E.M., C.E., ... 1877
Consulting Engineer, Kalgoorlie, W. Australia.
Nicholson, John M., A.B., C.E., ... 1903
Asst. Eng., Long Island R. R., New York.
Niemann, Edward, E.E., ... 1906
With Westinghouse Electric Co., Pittsburg, Pa.
Norris, Robert Van Arsdale, E.M., ... 1885
Consulting Engineer, Wilkesbarre, Pa.
Norseworthy, Howard R., E.M., ... 1904
Mining Engineer, 234 West 122d Street, New York City.
*Noyes, James Atkins, Ph.B., A.B., '83, ... 1878
Cambridge, Mass.
Noyes, William Skaats, E.M., ... 1875
Consulting Engineer, San Francisco, Cal.
Nusim, M. I., Mech.E., ... 1905
Turbine Research Dept., G. E. Co., Lynn, Mass.
Obert, Casin W., Mech.E., ... 1902
Assoc. Editor, Engineering Record, New York City.
O'Connor, Michael Joseph, E.M., Ph.B. (Arch.), . . 1881
Architect, 5 West 31st Street, New York City.
O'Donovan, Leo J., E.E., ... 1902
Engineer and Contractor, 268 West 91st Street, New York City.
Of, Charles, E.M., ... 1896
Mining Engineer, Puley's Island, N. F.
Olcott, Eben Erskine, E.M., ... 1874
Consulting Eng., 36 Wall Street, New York City.
Ormsbee, Alex. F., E.E., ... 1895
Engineer with N. Y. & N. J. Telephone Co.
Ormsbee, James Jackson, E.M., ... 1886
Supt. El Paso Smelting Works, El Paso, Tex.
Osterheld, T. W., E.M., ... 1886
Supt., Min. & Blasting Operation, Isthmian Can. Com., Panama; Consulting Eng., Republic of Panama.
Page, George Stevens, E.M., ... 1885
Asst. Mgr., Park Works, Crucible Steel Company of America.
Painter, Charles Albert, E.M., ... 1884
Engineer with Scully, Painter & Black, Pittsburg, Pa.

PAINTER, GEORGE EDWARDS, PH.B., ... 1883
Director, Safe Deposit & Trust Co., Pittsburg, Pa.

PAINTER, ROBERT K., E.M., ... 1896
Mgr., San Carlos Copper Co., Mexico.

PALMENBERG, OSCAR W., B.S. (Chem.), ... 1902
Chemist, Interborough R. T. Co., New York City.

PALMER, AUSTIN P., E.E., ... 1906
Asst. Eng., Met. St. Ry. Co., New York City.

PALMER, CORTLANDT E., E.M., ... 1878
Gen. Supt. of Mines, Guggenheim Ex. Co., 71 Broadway, New York City.

PALMER, MONTAGUE, E.E., ... 1903
Eng. Dept. of Bridges, New York City.

PARKER, HERSCHEL CLIFFORD, PH.B. (Chem.), . . . 1890
Adj. Professor in Physics, Columbia University, New York City.

PARKER, LINDSAY R., E.E., ... 1901
With Manhattan Railway Company, New York City.

PARKER, RICHARD ALEXANDER, C.E., E.M., ... 1878
Consulting Mining Engineer, Denver, Colo.

PARKS, JOHN RANDOLPH, E.M., ... 1880
Consulting Engineer, Spokane, Wash.

PARR, HARRY L., A.B., MECH.E., ... 1904
Yonkers, N. Y.

*PARRAGA, CHARLES FREDERICK, C.E., ... 1883

PARSONS, WILLIAM BARCLAY, A.B., C.E., ... 1882
Consulting Engineer, 22 William Street, New York City.

PATTBERG, OTTO FRED'K, E.M., ... 1898
Gen. Mgr., Montgomery Min. Co., North Carolina.

PAYNE, CLARENCE QUINTARD, E.M., ... 1882
Consulting Engineer, 99 John Street, New York City.

PEDERSON, FREDERICK M., E.E., M.S., ... 1893
Instructor, Brooklyn Polytechnic, Brooklyn, N. Y.

PEELE, ROBERT, E.M., ... 1883
Professor of Mining, Columbia University, and Consulting Mining Engineer, 36 Wall Street, New York City.

PELLEW, CHARLES ERNEST, E.M., ... 1884
Adj. Professor of Chemistry, Columbia University.

PELTON, E. F., B.S., E.M., ... 1902
Geologist, Detroit Copper Co., Arizona.

PELTON, ROGER T., E.M., ... 1903
Engineer, Copper Queen Min. Co., Bisbee, Ariz.

PEMBROKE, EARL R., E.M., ... 1903
Consulting Mining Engineer, Salt Lake City. Utah.

PERKINS, HARRY A., E.E., ... 1899
Professor of Physics, Trinity College, Hartford, Conn.

PERRINE, GEORGE, C. E., ... 1894
Consulting Engineer, 22 William St., New York City.

PEUGNET, CHARLES PAUL ERNST, C.E., A.M., . . . 1895
Asst. Eng., Hudson Companies, New York City.

PICKARD, GLENN H., B.S. (Chem.), ... 1904
Chemist, Spencer Kellogg Co., Buffalo, N. Y.

PICKHARDT, WILLIAM PAUL, B.S. (Chem.), ... 1901
Chemist, Continental Color & Chemical Co., New York City.

PIERCE, F.E., C.E., ... 1892
Engineer, New Jersey Zinc Co., 71 Broadway, New York City.

PIEZ, CHARLES, E.M., ... 1889
President, Link Belt Engineering Company, Chicago, Ill.

PIGOTT, REGINALD J. S., MECH.E., ... 1906
Asst. Eng., Interborough R. T. Co., New York City.

PIGOTT, STEPHEN J., MECH.E., ... 1903
Eng., Int. Curtis Marine Turbine Co., New York City.

PINKHAM, HERBERT, C.E., ... 1895
Supt., Astor Estate, Rhinebeck, N. Y.

PISTOR, WILLIAM, E.M., ... 1868
Architect, 68 Broad Street, New York City.

PITKIN, LUCIUS, A.B., PH.B. (Chem.), ... 1881
Consulting Chemist, 47 Fulton Street, New York City.

PITON, EUGENE, JR., A.B., C.E., ... 1906
Civ. Eng., Ridgelawn Cemeteries, Newark, N. J.

POLISHOOK, SAMUEL N., C.E., ... 1906
Eng. for J. B. Snook, Architect, New York City.

POLLEDO, YSIDORO YGNACIO, E.M., ... 1885
Consulting Engineer, Matanzas, Cuba.

POND, CHARLES M., MECH.E., ... 1903
Engineer for Niles, Bemont & Pond, New York City.

POPCKE, ARTHUR G., E.E., ... 1906
With Westinghouse Elec. Co., Pittsburg, Pa.

PORTER, H. HOBART, E.M., ... 1886
Consulting and Contracting Engineer, 52 William Street, New York City.

PORTER, JESSE C., E.M., ... 1905
Mining Engineer, Spanish-American Iron Co., Cuba.

PORTER, JOHN BONSALL, E.M., PH.D., ... 1882
Professor of Mining and Metallurgy, McGill University, Montreal, Can.

POWELL, FREDERICK, A.B., E.M., ... 1883
Engineer, Hammond Mfg. Co., Portland, Ore.

POWERS, LEWIS J., JR., E.M., ... 1884
Mgr., Powers Paper Co., Holyoke, Mass.

Powers, Walter H., E.E., ... 1902
Electrical Engineer and Contractor, 225 Fourth Avenue, New York City.

Preston, William Evan, C.E., ... 1889
With U. S. Engineer Corps, U. S. A.

Pretzfeld, Chas. J., Ph.D., ... 1898
Chemist, People's Gas, Light & Coke Co., Chicago, Ill.

Prince, John L., E.E., ... 1894
Inspector, New York Edison Company.

Prosser, Herman A., E.M., E.E., ... 1896
Metallurgical Director, U. S. S. & R. & M. Co., Chrome, N. J.

Prout, Glover P., C.E., ... 1903
Civil Engineer, Embruville, Tenn.

Provost, Andrew J., Jr., C.E., ... 1889
Sanitary Engineer, 520 Fifth Avenue, New York City.

Provot, F. A., C.E., ... 1893
Consulting Engineer, 11 East 42d Street, New York City.

Putnam, B. R., B.S., A.M., ... 1893
Supt., Bingham Cons. M. & S. Co., Utah.

Queneau, A. L. J., E.M., A.M., ... 1901
Metallurgist for Zinc Corp. of England, South Bethlehem, Pa.

Raisman, Aaron I., C.E., ... 1898
Asst. Eng., R. T. Com., New York City.

Randolph, E., Ph.B. (Chem.), ... 1882
Banker and Broker, New York City.

Ray, David H., A.B., B.S., 1901, A.M., C.E. (N. Y. U.), (Life Member), ... 1902
Architect and Engineer, Audubon Avenue, West 182d Street, New York City.

Raymond, Robert Matthew, A.B., E.M., ... 1889
Gen. Mgr., El Oro Min. & Ref. Co., Mexico.

Read, James P., E.E., ... 1906
Supt. of Constr. for J. S. Barstow & Co., New York City.

Read, Thomas T., E.M., ... 1902
Professor of Mining & Metallurgy, Colorado College.

Reckhart, Daniel William, E.M., ... 1884
Proprietor, Independent Assay Office, El Paso, Tex.

Reed, David C., E.M., ... 1900
Mining Engineer, Peru.

Reed, Silvanus Albert, A.B., A.M., E.M., ... 1877
Consulting Engineer, New York City.

Reich, Wm. J., Mech.E., A.M., ... 1902
Engineer and Contractor, Pittsburg, Pa.

Reis, Leslie Robert, Mech.E., ... 1902
Consulting Engineer, 609 West End Avenue, New York City.

Renault, George, C.E., ... 1883
Consulting Engineer, 170 West 87th Street, New York City.

Rhodes, Francis Bell Forsythe, E.M., ... 1874
Supt., U. S. Zinc Co., Pueblo, Colo.

Rice, George Samuel, E.M., ... 1887
Consulting Engineer, 734 Rookery Building, Chicago, Ill.

Richards, Howard, Jr., E.E., ... 1903
Principal, Boone School, China.

Richmond, Julian P. W., Mech.E., ... 1902
Asst. Eng., Board of Water Supply, New York City.

Ricketts, Pierre de Peyster, E.M., Ph.D., ... 1871
Consulting Engineer, 104 John Street, New York City.

Riedel, C. Oscar, Mech.E., ... 1904
P. O. Box 242, New York City.

Riederer, Emil J., B.S. (Chem.), ... 1897
Asst. Supt., Forcile Powder Co., Landing P. O., N. J.

Riederer, Herman S., A.M., Ph.D., ... 1901
Chemist, Krebs Pigment & Chem. Co., Newport, Del.

Ries, Heinrich, Ph.B., A.M., Ph.D., ... 1892
Professor of Geology, Cornell University, Ithaca, N. Y.

Rigby, S. F., E.M., ... 1902
Consulting Engineer, Salt Lake City, Utah.

Ring, Ambrose E., E.M., ... 1905
Surveyor, Butte, Mon.

Rionda, L. J., Mech.E., ... 1902
Consulting Engineer, Cuba.

Riter, Levi E., Jr., E.M., ... 1899
Consulting Engineer, Salt Lake City, Utah.

Roden, Benjamin Franklin, Jr., E.M., ... 1906
Gen. Mgr., Central Coal Co., Alabama.

Rodenburg, Charles, C.E., ... 1896
Asst. Eng., N. Y. Rapid Transit Commission.

Rodriguez, Varela Francisco, E.M., ... 1903
Mining Engineer, Mazapil, Zacatecas, Mex.

Rogers, Robert B., E.M., ... 1905
Min. Eng., Cobalt, Ont.

Rolker, Charles M., E.M., ... 1875
Consulting Engineer. Leadenhall Building, No. 1 Leadenhall Street, London, E. C., England.

Ros, Juan Pablo, B.A., E.M., ... 1898
Chief Engineer, Sta. Clara Province, Cienfuegos, Cuba.

ROSENBLATT, GIRARD B., E.E., ... 1902
Elect. Eng., Westinghouse Electric & Manufacturing Co. in Montana.

ROSENTHAL, ALBERT, C.E., ... 1892
Supt., Westchester Lighting Company.

ROSENTHAL, LEON W., E.E., ... 1902
Electrical Eng. Dept., N. Y. C. & H. R. R. R. Co.

ROSSBERG, WILLIAM N., E.M., ... 1904
Engineer, Centrifugal Separating Co., Frisco, Utah.

ROSSI, AUGUST J., E.M., ... 1896
Supt., Roessler & Hasslacher Chem. Co., Perth Amboy, N. J.

ROWLAND, CHARLES BRADLEY, C.E., ... 1884
The Continental Iron Works, Brooklyn, N. Y.

ROWLAND, GEORGE, C.E., ... 1887
Asst. Treas., The Continental Iron Works, Brooklyn, N. Y.

RUBIDGE, FREDK. TABER, E.M., C.E. (Univ. of Colo.), . . 1901
Asst. Supt. of Mines, The New Jersey Zinc Co., New Jersey.

RUTTMANN, FERDINAND, E.M., ... 1880
Consulting Engineer, 45 Broadway, New York City.

RYON, AUGUSTUS MEADER, E.M., ... 1886
Consulting Engineer, Flushing, N. Y.

SAGE, DARROW, E.E., ... 1901
Chief Eng., Sayles Bleacheries, Rhode Island.

SAGE, EDWARD EUGENE, C.E., ... 1887
Assayer, United States Assay Office, New York City.

DE SALLIER, RENÉ A., E.M., ... 1905
Asst. to R. M. Atwater, Consulting Engineer, Helena, Mont.

SANGUINETTI, PHILIP C., MECH.E., ... 1903
Eng., Maunick, Mitchell & Co., New York City.

SAUNDERS, GEO. CROSBY, B.S., C.E., ... 1898
In Iron and Steel Business, Boston, Mass.

SAYERS, EDWARD L., A.B., C.E., ... 1903
Asst. Eng., P., N. Y. & L. I. R. R. Co., 218 West 121st Street, New York City.

SAYRES, JOHN H., C.E., ... 1897
President, The Atlantic Company, Brooklyn, New York City.

SCHARF, HENRY WARREN, E.E., ... 1901
Engineer, Interurban Street Railway Company.

SCHAUS, CARL J., E.E., ... 1904
With General Electric Co., Schenectady, N. Y.

SCHELL, R. MONTGOMERY, B.S., ... 1895
Architect, 69 Wall Street, New York City.

SCHERMERHORN, FREDK. AUGUSTUS, E.M., ... 1868
Trustee, Columbia University.

SCHIEFFELIN, WILLIAM JAY, PH.B., PH.D., ... 1887
Manufacturing Chemist, Schieffelin & Co., 170 William Street, New York City.
SCHLOSSER, PHILIP, MECH.E., ... 1902
Mech. Engineer, 2 East 92d Street, New York City.
SCHNEIDER, ALBERT FRANCIS, E.M., C.E., ... 1876
Consulting Engineer, 77 Pine Street, New York City.
SCHNEIDER, CARL A., E.E., ... 1904
Asst. Eng., Consolidated Ry. Co., New York City.
SCHREIBER, CARL T., MECH.E., ... 1904
Mech. Eng., W. S. Barstow & Co., New York City.
SCHROEDER, J. LANGDON, C.E., ... 1889
Architect, 5 West 31st Street, New York City.
SCHROETER, GEO. A., E.M., ... 1893
Consulting Engineer, Denver, Colo.
SCHULTZ, R. S., JR., E.M., ... 1906
Engineer, Victoria Copper Co., Michigan.
SCHUMANN, CHARLES HENRY, C.E., ... 1888
Architect and Civil Engineer, 265 Broadway, New York City.
SCHWARZKOPF, WM., E.E., ... 1906
With Westinghouse Co., New York City.
SCHWERIN, CLARENCE MAURICE, E.M., ... 1901
Asst. Supt., Milwaukee Coke & Gas Co.
SCHWERIN, MARTIN, E.M., ... 1903
Consulting Mining Engineer, 49 Wall Street, New York City.
SCUDDER, HEWLETT J., E.E., M.A., ... 1899
With General Electric Co., Schenectady, N. Y.
SEARLE, CHARLES D., C.E., ... 1894
Asst. Eng., R. T. Com., New York City.
SEIFERT, H. F., E.M., ... 1906
With Tennessee Copper Co., Tennessee.
SEIL, HARVEY A., B.A., PH.D., ... 1906
Chemist for G. H. Harvey & Co., Saratoga Springs, N. Y.
SELDNER, RUDOLPH, PH.B., B.S., ... 1894
Manufacturing Chemist, 1395 Dean Street, Brooklyn, N. Y.
SELF, E. D., E.M., M.E., ... 1894
Gen. Mgr. San Carlos Copper Co., Mexico.
SERINGHAUS, FREDERICK W., JR., E.E., ... 1904
With Gen. Elect. Co., Schenectady, N. Y.
SESSINGHAUS, GUSTAVUS, E.M., M.S. (Univ. Wis., 1899), . 1898
Mgr., Thunderbolt Min. Co., Colorado.
SEWARD, JOHN, E.M., ... 1895
Mining Engineer, Tonopah, Nev.
SHARE, WILLIAM WALDEMER, PH.B. (Chem.), PH.D., . . 1881
Professor of Chemistry, Adelphi Acad., Brooklyn, N. Y.

SHATTUCK, L. R., B.S., C.E., ... 1895
Engineer for Sanderson & Porter, 52 William Street, New York City.
SHAW, S. F., E.M., ... 1903
Supt., Granadena Mill, Chihuahua, Mex.
SHERMAN, G. F., C.E., ... 1894
Asst. Supt., Copper Queen Con. Min. Co., Bisbee, Ariz.
SHERMAN, HENRY C., A.M., PH.D., ... 1896
Professor of Organic Analysis, Columbia University.
SHERREN, G. AUSTIN, E.M., ... 1904
Mining Engineer, Goldfields, Nev.
SHREVE, JOHN NELSON, E.M., ... 1902
Treas., Magnet Wire Co., 42 Broadway, New York City.
SHRIVER, HARRY TOWER, PH.B. (Chem.), ... 1888
Iron Foundry Works, Harrison, N. J.
SIGMUND, BENJAMIN J., C.E., ... 1906
Asst. Engr. in Concrete Constr., New York City.
SILVERMAN, HERBERT L., E.M., ... 1905
Mining Engineer, Butte, Mont.
SIMONDS, FRANCIS MAY, E.M., PH.D., ... 1887
Chemist and Mining Engineer, New York City.
SINCLAIR, J. EDWIN, B.S. (Chem.), ... 1906
Lecturer in Chemistry, Columbia University.
SINGER, GEORGE, E.M., ... 1880
Pittsburg Club, Pittsburg, Pa.
SINGER, GEORGE HARTON, E.M., ... 1880
With Crucible Steel Co., Pittsburgh.
SLADE, RICHMOND EDWARD, PH.B., ... 1887
Gen. Mgr. Gas Light Co., Hartford, Conn.
SLAVEN, R. E., E.E., ... 1899
Engineer Chase Granite Co., Blue Hill, Me.
SLOANE, T. O'CONNOR, JR., E.E., ... 1903
Engineer and Contractor, South Orange, N. J.
SMALLWOOD, JULIAN C., MECH.E., ... 1903
Draftsman Stan. Plunger Elevator Co., New York City.
SMILLIE, SHELDON, E.M., ... 1904
Asst. Min. Eng. Quincy Min. Co., Michigan.
SMITH, AUGUSTUS, A.B., C.E., ... 1889
Consulting Engineer, 39 Cortlandt Street, New York City.
SMITH, FRANK MARSHALL, E.M., ... 1889
Mgr. Am. S. & R. Co., East Helena, Montana.
SMITH, LENOX, A.B., A.M., E.M., ... 1868
Agent for R. R. interests, 71 Broadway, New York City.
SMITH, R. W., E.E., ... 1903
With I. R. T. Co., New York.

Smith, Webster Temple, E.M., ... 1904
Mgr. Cushman & Smith Ochre Works, Vermont.

Smith, William Allen, E.M., ... 1898
Supt. United Zinc and Chemical Co., Iola, Kansas.

Smith, Wilson Fitch, C.E., ... 1894
Div. Engr. Board of Water Supply, New York City.

Smyth, Charles Henry, Jr., Ph.B., Ph.D., ... 1888
Professor of Geology, Princeton Univ., New Jersey.

Snedeker, Clarence F., E.E., ... 1905
Elect. Dept. L. I. R. R. Co., New York City.

Snook, Thomas Edward, E.M., ... 1884
Architect, 261 Broadway, New York City.

Solomon, Isaac Rosh, E.E., ... 1902
Chief Electrician, Navy Yard, Pensacola, Fla.

Solow, Alexander S., B.S., C.E., ... 1904
Asst. Engr. R. T. Com., New York City.

Spaulding, M. B., E.M., ... 1895
Gen. Mgr. Peruvian S. & R. & Min. Co.

Spencer, J. Beaumont, Mech.E., ... 1906
Asst. Engr. James Reilly Repair and Supply Co., New York City.

Spiro, Walter J., A.B., Mech.E., ... 1903
Supt. Columbia Typewriter Co., New York City.

Spooner, Allen Newhall, C.E., ... 1886
Div. Engr. Department of Docks and Ferries, New York City.

Stangland, Robert S., Mech.E., ... 1904
Contracting Engineer, Morton, New York.

Stanley, R. E., E.M., ... 1901
Asst. Gen. Supt. the Oxford Copper Co., New Brighton, S. I.

Stanton, Frank McMillan, E.M., ... 1887
Agent Atlantic Mine, Mich.

Staral, Frank T., Jr., E.M., ... 1904
Min. Engr. Compaña de Real del Monte y Pachuca, Mexico.

Starr, Chas. C., A.M., ... 1902
Supt. Hardshell and Flux Mines, Arizona.

Staunton, William Field, E.M., ... 1882
Gen. Mgr. Imperial Copper Co., Tombstone, Arizona.

Stearns, Thomas Beale, E.M., ... 1881
Mining Machinery, Denver, Col.

Steel, A. A., E.M., ... 1902
Professor of Geol. and Min., Univ. of Arkansas.

Stein, Charles R., C.E., ... 1904
With P., N. Y. & L. I. R. R. Co.

Stevens, Earl C., E.M., ... 1905
Asst. City Engineer, Billings, Mont.

STEWART, HOWARD RACE, E.M., ... 1902
Engineer, Louisville, Ky.
STEWART, JOHN B., E.M., ... 1901
Supt. Cyanide Dept. Peregrina M. & M. Co., Mexico.
STEWART, JOHN HENRY, C.E., ... 1895
Consulting Engineer, 123 West 11th Street, New York City.
STONE, MASON A., JR., MECH.E., ... 1903
With Penna. R. R., Altoona, Pa.
STONE, GEORGE CAMERON, PH.B. (Chem.), ... 1879
Chemist, the New Jersey Zinc Company.
STOUTENBURGH, CHAS. H., E.E., ... 1905
Gould Storage Battery Co., New York City.
STOVER, RODERICK, E.E., ... 1903
Pres't S. W. Elect. and Constr. Co.
STRAUSS, LESTER, E.M., ... 1900
Consulting Min. Eng., Lima, Peru.
STRONG, CHESTER F., E.E., ... 1904
Test. Dept. Gen. Elect. Co., Schenectady, N. Y.
STRUTHERS, JOSEPH, PH.B. (Chem.), ... 1885
Asst. Ed., Sec. and Treas., A. I. M. E., 99 John Street, New York City.
*STUART, WILLIAM HENRY, C.E., ... 1886
43 Madison Avenue, Lakewood, N. J.
STURGIS, EDWARD BARNEY, E.M., ... 1895
Civil Engineer and Contractor, 307 East 17th Street, New York City.
SUTER, GEORGE AUGUSTUS, E.M., ... 1883
Engineer and Contractor for Steam Power, etc., New York City.
SWAIN, ALFRED ERNEST, E.M., ... 1881
Supt. Am. Zinc Exts. Co.'s Mines at Parall, Chihuahua, Mexico.
SWART, CLIFFORD T., MECH.E., ... 1881
Tutor in Mech. Eng., Columbia University.
SWARTZ, CHARLES C., A.M., E.M., ... 1904
Mining Engr., N. Y. City.
TALCOTT, M. GARDNER, E.M., ... 1905
Mining Engineer, Clifton, Arizona.
TANZ, ISADORE, E.E., ... 1906
With N. Y. Telephone Co.
TATLOCK, JAMES LLOYD, C.E., ... 1898
Asst. Engr., B. & O. R. R., Md.
TAYLOR, HENRY B., E.M., ... 1906
Draftsman, N. J. Zinc Co.
TENNILLE, GEO. F., PH.B. (Chem.), ... 1894
Dist. Mgr. So. Cotton Oil Co., Savannah, Ga.
TERHUNE, RICHARD HENRY, E.M., ... 1870
Supt. T. V. Smelting Co., Colo.

TER MEER, HENRY C., E.E., ... 1901
With N. Y. Telephone Co.
TERRY, R. RUFO, MECH.E., ... 1904
Mechanical Engineer, Sterling Co., Barberton, Ohio.
TETLEY, THOMAS, JR., C.E., ... 1904
Asst. Engr., N. Y. Barge Canal, Fulton, N. Y.
THACHER, ARTHUR, C.E., E.M., ... 1877
Mining Engineer, St. Louis, Mo.
THAYER, REGINALD H., E.M., ... 1901
Mining Engineer, Bisbee, Arizona.
THOMAS, FREDERICK MAYHEW, E.M., ... 1885
Chief Engineer, Sewer Com., Skaneateles, N. Y.
THOMPSON, HENRY C., C.E., ... 1886
Asst. Engineer, West Shore R. R., N. Y.
THOMPSON, JOHN FAIRFIELD, B.S. (Chem.), ... 1903
With Oxford Copper Co., New Jersey.
THURSTON, L. S., E.E., ... 1902
Engineer for Gen. Elect. Co., Cincinnati, Ohio.
THYNG, WILLIAM S., E.M., ... 1896
Gen. Mgr. Roselle Min. Co., Washington.
TIBBALS, GEORGE ATWATER, C.E., ... 1883
The Continental Iron Works, Brooklyn, N. Y.
TIBBALS, SAMUEL GAYLORD, C.E., ... 1884
The Continental Iron Works, Brooklyn, N. Y.
TIEMANN, HUGH PHILLIP, B.S. (Chem.), A.M., . . . 1900
With Carnegie Steel Company, Munhall, Pa.
TITCOMB, HAROLD A., A.B., E.M., ... 1898
Mining Engr. for J. Hays Hammond, N. Y. City.
*TITUS, WARREN HARRIOTT, E.M., ... 1885
111 Blackstone Boulevard, Providence, R. I.
TOMBO, CARL, B.S., C.E., ... 1902
Engr. on Tunnel Construction, Canada.
TONNELE, THEODORE, PH.B., ... 1880
Chemist, Wm. Dewees Wood Co., McKeesport, Allegheny Co., Pa.
Not in professional practice.
TOWER, A. E., E.M., ... 1883
Pres'd't Poughkeepsie Iron Co., Poughkeepsie, N. Y.
TRACY, WILLIAM E., A.B., E.M., ... 1904
Mining Engr., Liberty Bell Min. Co., Colorado.
TRAPHAGEN, FRANK WEISS, PH.B. (Chem.), PH.D., . . 1882
Professor of Metallurgy and Assaying, Colorado School of Mines.
TRIPPE, WM. H., E.E., ... 1905
Westinghouse Elect. and Mfg. Co., Pittsburg.
TRUAX, SEWALL, E.M., ... 1903
Gen. Mgr. Granadena Min. Co., Santa Barbara, Mex.

TUCKER, ARTHUR A., E.E., ... 1902
Banker, 308 West 94th Street, New York City.

TUCKER, SAMUEL A., PH.B., ... 1895
Adjunct Professor of Electro-Chemistry, Columbia University.

TUDOR, WILLIAM, JR., E.M., ... 1898
Supt. Santa Fé Gold and Copper Min. Co., New Mexico.

TUSKA, GUSTAVE ROBITSCHER, B.S., M.S., C.E., . . . 1891
Consulting Engineer, 62 William Street, New York City.

TUTTLE, EDGAR GRANGER, E.M., ... 1881
Consulting Mining Engineer, Germantown, Pa.

TUTTLE, WM. W., E.M., ... 1867
Consulting Engineer, 713 East Elm Street, Springfield, Mo.

TWEEDY, ANDREW M., E.M., ... 1906
Supt. American Pyntes Co., Gouverneur, N. Y.

TYLER, WALTER LINCOLN, C.E., ... 1887
Mgr. A. B. See Elevator Co., 220 Broadway, New York City.

TYLER, WILLIAM R., C.E., ... 1904
Surveyor for Astoria Light and Power Co., New York City.

UNGRICH, MARTIN J., E.M., ... 1902
Draftsman Dept. of Docks, New York City.

VAIL, LEWIS H., E.E., ... 1894
Asst. Elect. Engr., D., L. & W. R. R. Co., Scranton, Pa.

VANDERPOEL, FRANK, E.M., PH.D., ... 1875
Consulting Chemist, Orange, N. J.

VAN ARDSDALE, WILLIAM HENRY, A.B., A.M., E.M., . . . 1868
V.-Pres. Chicago and Aurora S. & R. Co., Aurora, Ill.

VAN CORTLANDT, EDWARD NEWENHAM, E.M., ... 1885
Consulting Engineer, Denver, Colo.

VAN DEVENTER, CHRISTOPHER, E.E., ... 1897
Engr. Stanley Electric Mfg. Co., Equitable Building, Boston, Mass.

VAN DYCK, WILLIAM VAN B., M.S. (Rutgers), E.E., . . 1897
Pres't Cronly Ceramic Co., Cronly, N. C.

VAN SINDEREN, HOWARD, PH.B. (Chem.), LL.B., . . . 1881
Lawyer, New York City.

VER PLANCK, WM. E., E.E., ... 1902
Asst. Engr., Gen. Elec. Co., Lynn, Mass.

VOM BAUR, C. H., E.E., ... 1895
Consulting Engineer, 681 79th Street, Brooklyn, N. Y.

VONDY, RUDOLPH HARRISON, E.M., ... 1882
Mining Engineer, New Smyrna, Fla.

VON FINTEL, ERNEST A., C.E., ... 1895
Asst. Engr. Blackwell's Island Bridge, New York.

VON NARDOFF, ERNEST ROBERT, E.M., ... 1886
Head of Science Dept., High School, Brooklyn, N. Y.

Von Schrenk, A., E.E., ... 1901
With G. E. Co., Turbine Dept.

Von Sholly, B. R., M.A., ... 1905
Gas Engineer, Power and Min. Mach. Co., Milwaukee, Wis.

Vredenburgh, Watson, Jr., C.E., ... 1898
Consulting Engineer, 50 Broadway, New York City.

Vulte, Herman T., Ph.B., Ph.D., ... 1881
Adj. Professor Domestic Science, Teachers College, Columbia University.

Wainwright, John Howard, Ph.B. (Chem.), ... 1882
Consulting Chemist, 159 Front Street, New York City.

Walker, Arthur Lucien, E.M., ... 1883
Director Amer. S. and R. Co., and Amer. Smelt. Securities Co., New York City.

Walker, Frederick Warwick, C.E., ... 1895
Asst. Engr. P., N. Y. & L. I. R. R. Co.

Walker, H. V., Ph.B., ... 1894
Chief Insp. Dept. of Health, Brooklyn, N. Y.

Waller, Elwyn, A.B., A.M., E.M., Ph.D., ... 1870
Consulting Chemist, 159 Front Street, New York City.

Walter, John C., E.E., ... 1904
Engineer Ford, Bacon & Davis, New York City.

Walz, Andrew, E.M., ... 1905
Mining Engineer, Cobalt, Ont.

*Wampold, Leo, Ph.B., ... 1888
627 New York Life Building, Chicago, Ill.

Ward, Delancy Walton, Ph.B., ... 1888
Professor of Chemistry, N. Y. Dental College.

Warren, Charles P., Ph.B. (Arch.), A.M. (1892) . . . 1890
Architect, 20 West 34th Street, New York City.

Waterhouse, Geo. B., Ph.D., ... 1906
Metallographist, Lackawanna Steel Co., Buffalo, N. Y.

Waters, Rossiter Lester, Mech.E., ... 1902
Engr. Columbian Reinforced Concrete Co.

Watson, Chas. E., E.M., ... 1902
Mining Engineer, Transvaal, South Africa.

Watson, Frank Whalley, E.M., ... 1904
Vice-Prest. Pacific Coast Constr. Co., Oregon.

Watson, Rolla Barnum, E.M., ... 1891
Consulting Engineer, Shannon Copper Co., Clifton, Arizona.

Weed, Walter Harvey, E.M., ... 1883
Geologist, U. S. Geological Survey.

Weeks, William Holden, Ph.B., ... 1889
Lawyer, 789 Madison Avenue, New York City.

Weichmann, Ferdinand G., Ph.B., Ph.D., F.C.S., . . . 1881
Consulting Chemical Engineer, 310 West 80th Street, New York City.

Weichsel, Oscar M., E.M., ...
Engineer Blue Ledge Mine, Medford, Oregon.

Weil, Athur B., E.E., ... 1902
Electrical Engineer, 1254 East Madison Avenue, Cleveland, Ohio.

Weinrich, Morris F., Mech.E., ... 1904
Asst. in Drafting, Columbia University.

Welch, Alexander McMillan, Ph.B. (Arch.), . . . 1890
Architect, 11 East 42d Street, New York City.

Welcke, Celestin J., Mech.E., ... 1902
With Amer. Belt and Screw Co., New York City.

Wemlinger, J. R., C.E., ... 1902
Pres't Wemlinger Steel Piling Co., 11 Broadway, New York City.

Werner, Gerard Bernard, A.B., E.E., ... 1905
Engineer with Ry. Elect. Power Co., New York City.

Westbrook, F. A., Mech.E., ... 1906
With N. Y. Telephone Co., New York City.

Westervelt, William Young, E.M., ... 1894
Consulting Mining Engineer, 100 William Street, New York City.

Wheatley, Joseph Y., C.E., ... 1886
Civ. Engr., Cold Spring, N. Y.

Wheeler, Bleecker L., E.M., ... 1905
Mining Engineer, Rhyolite, Nevada.

Wheeler, Herbert Allen, E.M., ... 1880
Consulting Mining Engineer, Roe Building, St. Louis, Mo.

White, Francis Joseph, E.E., ... 1902
Battery Engr., N. Y. C. & H. R. R. R.

White, Robert Davis, C. E., ... 1892
Banker, 20 Broad Street, New York City.

White, William S., E.M., ... 1882
Manuf'r of Building Papers, 116 Nassau Street, New York City.

Whitlock, Herbert Percy, C.E., ... 1889
Mineralogist New York State Museum, Albany, N. Y.

Whyte, Wm. De Burgh, E.M., ... 1902
Mining Engineer, Johannesburg, South Africa.

Wickes, L. Webster, Met.E., ... 1903
Supt. Ely Witch Copper Co., Ely, Nevada.

Wiener, William, A.M., Ph.B. (Chem.), ... 1891
Consulting Chemist, Newark, N. J.

Wilcox, Sidney H., E.M., ... 1906
Mgr. Baranca Mines Co., Central America.

WILLHÖFFT, FRIEDRICH O., MECH.E., ... 1904
Professor of Mechanical Engineering, School of Mining, Queen's University, Kingston, Ontario, Canada.

WILLIAMS, JOHN TOWNSEND, E.M., PH.B., ... 1873
Constructing Engineer and Mine Owner and Operator, 27 William Street, New York City.

WILLIAMS, ROBERT T., A.B., E.M., ... 1904
Gen. Supt. Clearfield and Ohio River Coal Co.

WILLIAMS, WILLIAM FISH, C.E., E.M., ... 1881
Civil Engineer, New Bedford, Mass.

WILLIAMSON, ALFRED, MECH.E., ... 1902
Mech. Engr., Dept. Water Supply, New York City.

WILLIAMSON, GEORGE N., JR., B.S. (Chem.), ... 1903
Chemist for Williamson & Co., Englewood, N. J.

WILLIS, BAILEY, E.M., C.E., ... 1878
Geologist, United States Geological Survey.

WILLIS, HARRY THOMAS, B.S., E.M., ... 1904
Mining Engineer, Champaign, Ill.

WILMOT, H. CLIFFORD, E.M., ... 1902
Supt. Gen. Dev. Co., Butte, Mont.

WILNER, E. RALPH, MECH.E., ... 1902
Gen. Mgr. Manhattan Screw Works.

WILSON, CHAS. H., E.M., ... 1902
Wilson-Maeulen Co., Pyrometers, New York City.

WILSON, HERBERT M., C.E., ... 1881
Geographer, United States Geological Survey.

WILSON, L. G., MECH.E., ... 1902
Manufacturer, Norfolk, Va.

WILSON, WILLIAM ALEXANDER, E.M., ... 1882
Consulting Mining Engineer, Salt Lake City, Utah.

WILTSEE, ERNEST ABRAM, E.M., ... 1885
Consulting Engineer, 15 Broad Street, New York City.

WINETRAUB, A. I. M., E.E., ... 1905
Chief of Engr. Dept., Sussdorf, Taldo & Co., New York City.

WITHERELL, CHARLES S., MET.E., ... 1896
Supt. of Copper Dept., A. S. & R. Co., Maurer, N. J.

WITTEMAN, RUDOLPH W., MECH.E., ... 1902
Supt. Eng. Dept., Witteman Bros., New York City.

WITTMACK, CHARLES AUGUSTUS, M.S., PH.B. (Chem.), PH.D. 1882
Consulting Chemist, 606 West 113th Street, New York City.

WOOD, DENNISTOUN, JR., MECH.E., ... 1902
Asst. Engineer of Tests, So. Pacific Co., Sacramento, Cal.

WOOLSON, IRA HARVEY, E.M., ... 1885
Adj. Professor of Civil Engineering, Columbia University, New York City, and 201 Franklin Street, Astoria, N. Y.

Wormser, Moritz, A.B., C.E., ... 1903
Civil Engineer, Lakewood, N. J.

Wyckoff, Chas. R., C.E., ... 1902
Asst. Engr. N. Y. Board of Water Supply.

Wyld, Robert H., Mech.E., ... 1904
Mgr. for Power Specialty Co., St. Louis, Mo.

Yates, William H., C.E., ... 1903
Tutor in Civil Engineering, Columbia University.

Young, A. B., E.M., ... 1906
Metallurgical Staff of Canadian Copper Co., Canada.

*Young, Edward L., E.M., ... 1882
317 West 89th St., New York City.

Youtz, L. A., Ph.D. (Chem.), ... 1902
Professor of Chemistry, Lawrence University, Appleton, Wis.

Yrizar, Roberto, A.B., E.M., ... 1895
Gen. Mgr. Santa Ana Mines, Catorce, Mexico.

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Columbia University Bulletin of Information

SCHOOLS OF MINES, ENGINEERING AND CHEMISTRY

MINING

METALLURGY

CIVIL ENGINEERING

ELECTRICAL ENGINEERING

MECHANICAL ENGINEERING

CHEMICAL ENGINEERING

CHEMISTRY

ANNOUNCEMENT

1908-1909

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These include:

1. The Report of the President and the Treasurer to the Trustees.
2. The Catalogue of the University, issued in December, price 25 cents.
3. The Announcements of the several Colleges, Schools, and Divisions, issued in the spring, and relating to the work of the next year. These are made as accurate as possible, but the right is reserved to make changes in detail as circumstances require. The current number of any of these Announcements will be sent without charge upon application to the Secretary of the University.

B-8000—1908

HAVEMEYER Fayerweather ENGINEERING Earl Hall Hamilton SCHOOL OF MINES

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THE FACULTY OF APPLIED SCIENCE

Officers of the Faculty

NICHOLAS MURRAY BUTLER.............. *President of the University*
A.B., Columbia, 1882; A.M., 1883; Ph.D., 1884; LL.D., Syracuse, 1898; Tulane, 1901; Johns Hopkins, Princeton, Yale, and University of Pennsylvania, 1902; Chicago, 1903; Manchester and St. Andrew's, 1905; Cambridge, 1907; Litt.D., Oxford, 1905.

FREDERICK ARTHUR GOETZE........................*Dean of the Faculty*
M.Sc., Columbia, 1905.

J. HOWARD VAN AMRINGE..................*Professor of Mathematics*
A.B., Columbia, 1860; A.M., 1863; L.H.D., 1890; Ph.D., University of the State of New York, 1877; LL.D., Union, 1895.

CHARLES F. CHANDLER................*Mitchill Professor of Chemistry*
A.M., Ph.D., Göttingen, 1856; M.D., University of New York, 1873; LL.D., Union, 1873; Sc.D., Oxford, 1900.

HENRY S. MUNROE...........*Professor of Mining, and Delegate to the University Council*
E.M., Columbia, 1869; Ph.D., 1876; Sc.D., 1904.

ALFRED J. MOSES..........................*Professor of Mineralogy*
E.M., Columbia, 1882; Ph.D., 1890.

JAMES FURMAN KEMP..........................*Professor of Geology*
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E.M., Columbia, 1883.

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FRANCIS B. CROCKER..............*Professor of Electrical Engineering*
E.M., Columbia, 1882; Ph.D., 1895.

MICHAEL IDVORSKY PUPIN.............*Professor of Electro-Mechanics*
A.B., Columbia, 1883; Sc.D., 1904; Ph.D., Berlin, 1889.

WILLIAM H. BURR.....................*Professor of Civil Engineering*
C.E., Rensselaer Polytechnic, 1872.

THOMAS SCOTT FISKE......................*Professor of Mathematics*
A.B., Columbia, 1885; A.M., 1886; Ph.D., 1888.

HAROLD JACOBY..................*Rutherfurd Professor of Astronomy*
A.B., Columbia, 1885; Ph.D., 1895.

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B.S., Harvard, 1869; A.M., 1872; LL.D., 1905; B.S., Mass. Institute of Technology, 1871; LL.D., Lehigh, 1905; LL.D., Harvard, 1905.

CHARLES E. PELLEW..................*Adjunct Professor of Chemistry*
E.M., Columbia, 1884.

EARL B. LOVELL......................*Professor of Civil Engineering*
C.E., Cornell, 1891.

CHARLES RUSSELL RICHARDS.....*Macy Professor of Manual Training in Teachers College*
B.S., Massachusetts Institute of Technology, 1885.

GEORGE FRANCIS SEVER.............*Professor of Electrical Engineering*
M.Sc., Columbia, 1905.

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C.E., Columbia, 1888; Ph.D., 1899.

MARSTON TAYLOR BOGERT.............*Professor of Organic Chemistry*
A.B., Columbia, 1890; Ph.B., 1894.

J. LIVINGSTON RUTGERS MORGAN......*Professor of Physical Chemistry*
B.S., Rutgers, 1892; A.M. and Ph.D., Leipzig, 1895.

AMADEUS W. GRABAU.....................*Professor of Palæontology*
S.B., Massachusetts Institute of Technology, 1896; S.M., Harvard, 1898; S.D., 1900.

RALPH EDWARD MAYER....*Adjunct Professor of Engineering Drafting and Secretary of the Faculty*
C.E., Columbia, 1879.

IRA H. WOOLSON..............*Adjunct Professor of Civil Engineering*
E.M., Columbia, 1885.

CASSIUS JACKSON KEYSER ....*Adrain Professor of Mathematics*
B.S., Missouri, 1892; A.M., Columbia, 1896; Ph.D., 1901.

HERSCHEL C. PARKER...................*Adjunct Professor of Physics*
Ph.B., Columbia, 1890.

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M.D., New York University, 1896; B.S., Harvard, 1902; A.M., Columbia, 1904.

LEA McILVAINE LUQUER.............*Adjunct Professor of Mineralogy*
C.E., Columbia, 1887; Ph.D., 1894.

JAMES S. C. WELLS........*Adjunct Professor of Analytical Chemistry*
Ph.B., Columbia, 1875; Ph.D., 1877.

JOSEPH C. PFISTER....................*Adjunct Professor of Mechanics*
A.B., Columbia, 1889; A.M., 1890.

HENRY CLAPP SHERMAN................*Professor of Organic Analysis*
B.S., Maryland Agricultural College, 1893; A.M., Columbia, 1896; Ph.D., 1897.

ALBERT P. WILLS....................*Adjunct Professor of Mechanics*
B.E.E., Tufts, 1894; Ph.D., Clark, 1897.

SAMUEL A. TUCKER...........*Adjunct Professor of Electro-Chemistry*
Ph.B., Columbia, 1895.

ADOLPH BLACK................*Adjunct Professor of Civil Engineering*
C.E., Columbia, 1894.

CHARLES EDWARD LUCKE..........*Professor of Mechanical Engineering*
B.S., College of the City of New York, 1895; M.S., New York University, 1899; Ph.D., Columbia, 1902.

WALTER RAUTENSTRAUCH.........*Professor of Mechanical Engineering*
B.S., University of Missouri, 1902; M.S., University of Maine, 1903.

WILLIAM CAMPBELL..............*Adjunct Professor of Metallography*
B.Sc., Durham University, 1898; D.Sc., 1905; M.Sc., Royal School of Mines, 1903; Ph.D., Columbia, 1903; A.M., 1905.

CARLTON CLARENCE CURTIS................*Adjunct Professor of Botany*
A.B., Syracuse, 1889; Ph.D., 1893; A.M., Columbia, 1892.

EDWARD LAWRENCE KURTZ...............*Adjunct Professor of Mining*
E.M., Columbia, 1893.

ARTHUR L. WALKER.........................*Professor of Metallurgy*
E.M., Columbia, 1883.

Associates

JAMES M. DODGE................*Associate in Mechanical Engineering*

Instructors

CHARLES C. TROWBRIDGE..........................*Instructor in Physics*
B.S., Trinity, 1892; M.S., 1903.

GEORGE H. LING............................*Instructor in Mathematics*
A.B., University of Toronto, 1893; A.M., Columbia, 1894; Ph.D., 1896.

GEORGE BRAXTON PEGRAM.........................*Instructor in Physics*
A.B., Trinity College (N. C.), 1895; Ph.D., Columbia, 1903.

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MORTON ARENDT...................*Instructor in Electrical Engineering*
E.E., Columbia, 1898.

VICTOR J. CHAMBERS.................*Instructor in Organic Chemistry*
B.S., University of Rochester, 1895; Ph.D., Johns Hopkins, 1901.

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B.S., Rutgers, 1896; A.M., Columbia, 1900; Ph.D., 1901.

CHARLES PETER BERKEY........................*Instructor in Geology*
B.S., University of Minnesota, 1892; M.S., 1893; Ph.D., 1897.

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Ph.B., Buchtel, 1899; Ph.D., Columbia, 1902.

HARRY L. PARR..................*Instructor in Mechanical Engineering*
A.B., Columbia, 1902; Mech.E., 1904.

SAMUEL OSGOOD MILLER.......................*Instructor in Drawing*
C.E., Columbia, 1895.

EDWARD F. KERN..........................*Instructor in Metallurgy*
B.S., University of Tennessee, 1897; Ph.D., Columbia, 1901.

Tutors

CAVALIER HARGRAVE JOÜET.............*Tutor in Analytical Chemistry*
Ph.B., Columbia, 1882; Ph.D., 1894.

THOMAS H. HARRINGTON.......................... *Tutor in Drawing*
C.E., Columbia, 1889.

ARTHUR COLON NEISH.......................... *Tutor in Chemistry*
A.B., Queen's University, 1898; A.M., Columbia, 1900; Ph.D., 1904.

CHARLES H. ELLARD.................... *Tutor in Analytical Chemistry*
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HAL T. BEANS....................... *Tutor in Analytical Chemistry*
B.S., University of Nebraska, 1899; A.M., 1900; Ph.D., Columbia, 1904.

MAURICE A. LAMME.............................. *Tutor in Mineralogy*
B.S., Montana Agricultural College, 1903; A.M., Columbia, 1904.

ARTHUR RAY MAXSON.......................... *Tutor in Mathematics*
A.B., Rollins, 1900; A.M., Columbia, 1905.

LEWIS P. SICELOFF............................. *Tutor in Mathematics*
A.B., Central College, 1900.

CHARLES E. MORRISON...................... *Tutor in Civil Engineering*
B.S., College of the City of New York, 1897; C.E., A.M., Columbia, 1901.

OTTO KRESS.. *Tutor in Chemistry*
B.S., Columbia, 1906; A.M.

KAUFMAN G. FALK................................ *Tutor in Physics*
B.S., Columbia, 1901; Ph.D., Strassburg, 1905.

——————.................. *Tutor in Electrical Engineering*

CHARLES W. THOMAS................ *Tutor in Mechanical Engineering*
M.E., Stevens Institute.

Lecturers

MYRON S. FALK........................ *Lecturer in Civil Engineering*
C.E., Columbia, 1899; Ph.D., 1904.

WILLIAM S. DAY............................... *Lecturer in Physics*
A.B., Columbia, 1884; Ph.D., Johns Hopkins, 1897.

ELIHU C. CHURCH..................... *Lecturer in Civil Engineering*
C.E., Columbia, 1904.

DOUIS DOELLING................. *Lecturer in Mechanical Engineering*

RICHARD T. LINGLEY............. *Lecturer in Mechanical Engineering*

FRED W. O'NEIL................. *Lecturer in Mechanical Engineering*

FRED OPHULS..................... *Lecturer in Mechanical Engineering*

WILLIAM P. WHITE............. *Lecturer in Mechanical Engineering*

Assistants

WILLIAM C. UHLIG.................. *Assistant in Analytical Chemistry*
Ph.B., Columbia, 1896; Ph.D., 1904.

JAMES S. MACGREGOR................... *Assistant in Civil Engineering*
B.S., Massachusetts Institute of Technology, 1902; M.S., 1904.

JULIAN BLANCHARD............................Assistant in Physics
A.B., Trinity College (N. C.), 1905.

EDWIN KIRK............................Assistant in Palæontology
A.B., Columbia, 1907.

HARRY WILFRED REDDICK....................Assistant in Mathematics
A.B., Indiana, 1904; A.M., University of Illinois, 1906.

WILLARD L. SEVERINGHAUS......................Assistant in Physics
A.B., German Wallace College, 1904; A.M., 1905.

EDWARD D. THURSTON, JR.........Assistant in Mechanical Engineering
A.B., Columbia, 1905; Mech.E., 1907.

REINHARD A. WETZEL............................Assistant in Physics
B.S., University of Minnesota, 1901.

ALFRED HOFFMAN....................Assistant in Organic Chemistry
A.B., Columbia, 1903; A.M., 1904; Ph.D., Berlin, 1907.

CHARLES A. ISAACS........................Assistant in Mathematics
A.B., University of Indiana, 1905.

CHARLES B. MARKHAM............................Assistant in Physics
A.B., Trinity College (N. C.), 1906; A.M., 1907.

ROLAND CALBERLA....................Assistant in Electro-Chemistry

GAILLARD S. ROGERS........................Assistant in Mineralogy

DORRIS WILLIAM WHIPPLE..........Assistant in Analytical Chemistry
Ph.G., N. Y. College of Pharmacy; B.S., Columbia, 1908.

————————............................Assistant in Physics

————————............................Assistant in Physics

————————.....................Assistant in Civil Engineering

————————.....................Assistant in Civil Engineering

————————................Assistant in Electrical Engineering

————————................Assistant in Electrical Engineering

————————...................Assistant in Physical Chemistry

————————..........................Assistant in Metallurgy

Non-Resident Lecturers for 1907-08

WILLIAM BARCLAY PARSONS, C.E., Consulting Engineer, New York City.

R. V. NORRIS, E.M., Consulting Engineer, Pennsylvania Coal Companies.

ST. JOHN CLARK, C.E., Chief Engineer, N. Y. & L. I. R. R. Co.

FREDERICK A. HALSEY, M.E., Editor, "American Machinist," New York City.

ALLEN HAZEN, M.A., Consulting Engineer, New York City.

GEORGE C. WHIPPLE, B.Sc., Consulting Sanitary Engineer, New York City.

Daniel D. Jackson, Mt. Prospect Laboratory, Brooklyn.

Howard W. Du Bois, Mining Engineer, Philadelphia, Pa.

Geo. C. Stone, E.M., Chief Engineer, New Jersey Zinc Co.

Irving A. Chanler, Manager, Forbes Sterilizer Co., New York City.

J. O. Ellinger, Reinforced Cement Construction Co., New York City.

W. L. R. Emmett, M.E., General Electric Co., Schenectady, N. Y.

Frederick H. Ball, M.E., General Manager, American Engine Co.

Frank W. O'Neil, M.E., Engineer, Nordberg Manufacturing Co., New York City.

Schuyler S. Wheeler, President, Crocker-Wheeler Co., Ampere, N. J.

J. Ralph Finlay, Consulting Mining Engineer, New York City.

Thomas H. Leggett, E.M., Consulting Mining Engineer, New York City.

A. A. Blow, Consulting Mining Engineer, New York City.

James Douglas, LL.D., President of the Copper Queen Mining Company.

Richard G. G. Moldenke, E.M., Ph.D., Consulting Metallurgist.

Capt. Robert W. Hunt, Consulting Engineer, New York and Pittsburgh, Pa.

Rossiter W. Raymond, Ph.D., LL.D., Secretary, The American Institute of Mining Engineers.

Frederick R. Hutton, E.M., Ph.D., Sc.D., President, American Society of Mechanical Engineers.

M. Hollander, M.E., Otis Elevator Co., New York City.

Harold W. Buck, E.E., Consulting Engineer of the Niagara Falls Power Co.

Salisbury M. Day, E.E., Engineer, General Railway Signal Co., New York City.

Henry L. Doherty, Vice-Pres, and Consulting Engineer, American Light and Traction Co., New York City.

C. H. Sharp, Ph.D., Electrical Testing Laboratories, New York City.

H. St. Clair Putnam, M. Sc., Consulting Engineer, New York City.

William W. Lighthipe, E.E., Otis Elevator Co., New York City.

Standing Committees of the Faculty

On Administration. The Dean (Chairman), Professors Van Amringe, Peele, Lovell and Sever.

On Admissions. Professors Mayer (Chairman), Pfister, Sherman, Black and Rautenstrauch.

University Officers of Administration

Frederick P. Keppel, A.B. . . . . *Secretary of the University*
Rudolf Tombo, Jr., Ph.D. . . . . *Registrar of the University*
Charles S. Danielson . . . . *Bursar*
Henry L. Norris, M.E. . . . . . *Superintendent of Buildings and Grounds*

Librarian of the University

James H. Canfield, LL.D., Litt.D. (Oxon.)

Chaplain of the University

Raymond C. Knox, B. D.

Medical Director of the Gymnasium

George L. Meylan, M.D.

Secretary of Earl Hall

James Myers, A.B.

University Medical Visitor

D. Stuart Dodge Jessup, M.D.

COLUMBIA UNIVERSITY

Columbia University was founded in 1754 as King's College. In 1784, after the Revolutionary War, King's College became, by act of the Legislature of the State of New York, Columbia College. The institution whose name was thus changed has become Columbia University.

The first step for the foundation of a School of Applied Science was taken in 1864, when the Trustees approved the creation of a School of Mines, in which courses were later established in civil engineering, chemistry, and metallurgy. The growth of these courses, and the addition of the course in architecture during the decade of 1880 to 1890, made it seem desirable to adopt some more comprehensive name than the historic title "School of Mines," so that in 1896 the Schools of Engineering and Chemistry were set off from the School of Mines, the three schools remaining, however, under the jurisdiction of a single faculty.

SCHOOLS UNDER THE FACULTY OF APPLIED SCIENCE

The Faculty of Applied Science has charge of the following schools:

1. The School of Mines, with four-year courses leading to the degrees of Engineer of Mines and of Metallurgical Engineer.

2. The Schools of Engineering, with four-year courses in Civil Engineering, Electrical Engineering, and Mechanical Engineering, leading to the degrees of Civil Engineer, Electrical Engineer, and Mechanical Engineer respectively.

3. The School of Chemistry, with four-year courses, leading to the degrees of Chemist and Chemical Engineer.

The courses are intended to meet the requirements of the several professions indicated. Many of the courses permit a certain amount of specialization, particularly in the fourth year. The courses in the School of Mines are so arranged that the student can emphasize the engineering, the metallurgical, or the geological side of his profession.

A course in Sanitary Engineering (leading to the degree of Civil Engineer) is provided for those who wish to prepare themselves for this important branch of civil engineering.

Candidates for a professional degree who have some special end in

view are sometimes permitted to vary the regular course by substituting, for the courses ordinarily prescribed, courses for other degrees offered under the Faculty of Applied Science. No provision is made for partial courses under this Faculty. Students holding an academic degree who become candidates for the degree of Master of Arts or Doctor of Philosophy may offer work in one or more of these branches of technology either as a major or a minor subject under the Faculty of Pure Science and will be given opportunity for special study and investigation (see page 20). Non-matriculated students, properly qualified by age, special training and experience and by ability, may sometimes pursue advanced studies or original research.

ADMISSION

Except for reasons of weight, candidates for admission to the first-year class must be at least eighteen years of age at the time of matriculation, and correspondingly older for admission to advanced standing. Each candidate must before admission present a certificate of good moral character from his last teacher or from some citizen of good standing. Students from other colleges or universities must bring certificates of honorable dismission. Students are admitted subject to the disciplinary powers of the University authorities.

All requests for information regarding admission should be addressed to the Secretary of the University.

Collegiate Preparation Recommended

The liberal training offered by a preliminary Collegiate Course is quite as important to engineers, metallurgists and chemists as to lawyers, physicians or clergymen, and is strongly recommended by the Faculty of Applied Science. This, however, does not and should not involve a residence of eight years in college and technical school before a candidate receives the professional degree.

A graduate of any good college who has selected his course with reference to future work in applied science is able to complete the requirements for a degree in the Schools of Mines, Engineering and Chemistry in less than four years after receiving the Bachelor's degree. The opportunities for close articulation between Columbia College and these Schools are, however, particularly good. Under the provisions of the new program it is possible for a well-prepared student to complete the requirements for both the collegiate and professional degrees in a period of six, five and a half, or five years. A specimen curriculum of this combined course will be found on page 126.

Requirements for Admission for Students without Collegiate Preparation

To the First Year Class

Every candidate must offer at the entrance examinations (see below) subjects amounting to fifteen "points." A point represents a course of five periods a week for one year in the secondary school.

	Counting in Points	
Total requirement	15	points
The candidate must offer:		
Chemistry	1	"
Drawing	1	"
Elementary French *or* Elementary German	2	"
English	3	"
Mathematics	4	"
Physics	1	"

and three points from the following, subject to the restriction that to offer an advanced subject will involve offering either at the same time or earlier the corresponding elementary subject:

Elementary German *or* Elementary French — *see above*	2	points
Elementary Spanish	2	"
Elementary Latin	2	"
Intermediate French	1	"
Intermediate German	1	"
Ancient History	1	"
Modern and Mediæval History	1	"
American History	1	"
English History	1	"
Botany	1	"
Physiography	1	"
Zoölogy	1	"
Shopwork	1	"
Advanced Physics	1	"

Candidates for degrees of Engineer of Mines, Metallurgical and Chemical Engineer or Chemist, are recommended to offer Elementary and Intermediate German.

It is suggested that candidates deficient in entrance subjects in June arrange to take courses in them in the Summer Session of

Columbia University, the announcement of which will be sent upon application to the Secretary of the University.

Entrance Examinations

Examinations for admission will be held in 1908, beginning June 15 and September 14 respectively, and in January, 1909, beginning on the 18th. The June examinations are those of the College Entrance Examination Board. These are held at Columbia University and at about 140 other places, including, in 1908, Portland, Me.; Boston and Springfield, Mass.; Hartford and New Haven, Conn.; Albany and Buffalo, N. Y.; Newark, N. J.; Allegheny and Philadelphia, Pa.; Baltimore, Md.; Washington, D. C.; Asheville, N. C.; Louisville, Ky.; Memphis, Tenn.; New Orleans, La.; Cincinnati and Cleveland, Ohio; Indianapolis, Ind.; Chicago, Ill.; Detroit, Mich.; Milwaukee, Wis.; Minneapolis, Minn.; Kansas City and St. Louis, Mo.; Denver, Colo.; Salt Lake City, Utah; Portland, Oregon; Los Angeles, Cal.; and in Europe, London, Paris, Geneva. The September and January examinations, conducted by the University Committee on Entrance Examinations, are held only at the University.

A candidate may present himself at any of the scheduled series of examinations subject to the following restrictions:

Division of Examinations

1. He may not present himself at more than four series of examinations except by special consent of the Committee on Admissions.
2. At the first and the second series credit will be given for only such subjects or lettered (or numbered) parts of a subject as are approved by his principal instructor.
3. The results of an examination shall stand to his credit for twenty-nine months, but no longer.

A copy of the time-scheme of the examinations, together with information as to the proper method of filing application blanks for these examinations, the payment of fees, and the division of examinations, and also detailed definitions of the requirements in each subject which may be counted for admission, is given in the *Announcement of Admission and Entrance Examinations for* 1908, which may be had upon application to the Secretary of the University.

Report of Entrance Examinations

Each candidate taking examinations with the College Entrance Examination Board in June should send the report thereon to the Registrar of Columbia University immediately upon its receipt. He will then be advised as soon as possible whether he has been admitted with or without conditions, or in what subjects he must present himself for reëxamination.

In September candidates who wish to enter the University at once may obtain the results of their examination by calling at the Regis-

trar's Office on, or after, Tuesday, September 22, 1908. Others will be advised later by mail.

Certificates of Acceptance

The Committee on Admissions accepts in lieu of its entrance examinations no credentials of any sort except the Regents' Academic Diploma[1], the Regents' College Entrance Diploma[1], and the certificates of approved colleges, and these only for the subjects which they specifically cover. The certificates of the preparatory or high school departments of universities and colleges are not accepted. Candidates must take the regular entrance examinations in the subjects in which their certificates are not deemed adequate. All certificates so offered must be received at least one week before the first day of the entrance examinations (in 1908 before September 7), and the names of those whose certificates are accepted in whole or in part will be posted at least one day before the examinations begin.

To Advanced Standing

The adoption of the uniform first year in the Schools of Mines, Engineering and Chemistry in 1907, and the revision of the subsequent years of the professional courses, has made it possible for graduates of colleges and scientific schools to enter Columbia University with advanced standing and to complete the requirements for a professional degree without undue delay through conflicts and other causes. It is very desirable, however, that students in other colleges who are planning after graduation to take professional work should get into correspondence with the University as early as possible. If this is done they may receive advice with regard to the most advantageous collegiate subjects to elect, and also with regard to the summer courses of Columbia University. It sometimes happens that by taking certain summer work at the University in advance a student may save six months or a year in entering upon his professional career. A separately printed leaflet on admission to advanced standing in the Schools of Mines, Engineering and Chemistry will be sent on application to the Secretary of the University.

Candidates for admission from other universities or colleges, and those desiring to be admitted to advanced standing on examination, should make application in writing to the Chairman of the Committee on Admissions of the Faculty of Applied Science in time to reach him before September 7, 1908.[2] The application must be

[1]By forwarding a copy of the diploma to the Secretary of the University the holder of an Academic Diploma may learn to what extent the subjects covered by it will be accepted in lieu of entrance examination.

[2]When the candidate is at a considerable distance from the University, his application should, if possible, be made earlier than September in order that he may receive the reply in time to present himself at the University on September 14, 1908.

accompanied by properly certified official statements of his standing in the subjects which he offers.

A candidate may be admitted notwithstanding deficiencies in some of these studies, but no candidate will be recommended for a professional degree until he shall have completed all the studies required for that degree.

No applicant will be allowed to enter the fourth-year class as a candidate for a degree after October 15 in any year.

The Committee on Admissions will notify the candidate by mail at the address given in his letter, between September 8 and 12, 1908, what courses, of those offered, are accepted as equivalent to courses at Columbia University. The Committee gives credit for complete courses only. In cases where the work previously done by the candidate has not been accepted by the Committee, the candidate may present himself for examination during the two weeks immediately preceding the opening of the University (in 1908, September 14-19), at the times and places at which the regular fall examinations are held. When no regular examination is held for the course at this time, the candidate may present himself for examination between the hours of 10 A.M. and 12 M. at the office of the Dean. The schedule of fall examinations is to be obtained from the Registrar.

In cases where credit for part of a course might be given, the candidate will present his case to the chairman of the Committee on Admissions, at the times given above, for final adjustment. He should bring with him drawings, note-books, or other evidence showing the scope and character of the work for which he wishes credit.

Admission to Special Courses

Graduates of the Schools of Mines, Engineering and Chemistry, and of other institutions of equal grade, may pursue any subjects taught in the schools for which they are properly qualified.

Except for reasons of weight satisfactory to the Committee on Admissions no one will be admitted as a non-matriculated student who, within ten months of the time of his application, has been refused admission, or has failed in his work, as a candidate for a degree.

Persons who wish merely to pursue elementary subjects, such as may be offered for admission, are not received as non-matriculated students.

Persons of mature age who are not graduates, but who show special qualifications, are sometimes permitted to pursue special courses, but this permission is not given to others.

Non-matriculated students will be held to the observance of the same regulations as to attendance, examination, proficiency, and deficiency as matriculated students.

Admission on Probation

Every first-year student admitted conditionally will be held under probation during the first half-year of residence. So far as possible, students on probation are given the opportunity in Columbia College or in the Department of Extension Teaching, to make good their deficiencies. Not later than the end of this period, the Dean, on the basis of reports from the head of each department in which the student is registered, will decide whether he shall be admitted to full standing, have his period of probation extended, or be dropped from the roll. The mark of 7 or higher, obtained in any subject at the end of the first half-year of residence, will be regarded as removing an entrance condition in that subject, unless the condition was incurred in a part of the subject not directly involved in the work of the course. Any condition not so removed must be satisfied by formal examination.

REGISTRATION

Before attending any University exercises each student must register, *i. e.*, must present himself in person to furnish the information necessary for the University records and to file a statement of the courses he is authorized to pursue (for the matriculation or registration fee, payable but once, see below).

The office of the Registrar, 201 East Hall, will be open for registration from Wednesday, September 16, to Tuesday, September 22, 1908. New students may register also on Wednesday, September 23, 1908.

Students prevented, through no fault of their own, from completing their registration in due time, should file a provisional registration-record.

Registration at a later date is permitted only to candidates who obtain the written consent of the Dean, satisfactory cause for the delay having been shown. (For the fee for late registration see below.)

Credit for attendance will date from September 23.

Students holding scholarships are required to report themselves as in residence to the Registrar at the opening of each half-year.

Honorable Dismissal

In case of withdrawal during the academic year, students are requested to file a notice thereof with the Registrar, on a blank form provided for the purpose. An honorable discharge is always granted by the Dean to any student of good standing over twenty-one who may desire to withdraw, and, with the written assent of his parent or guardian, to a student under that age. Applications for leave of absence must be addressed to the Dean.

FEES

The President is under instructions to withdraw the privileges of any student delinquent in payment after the second Wednesday of each half-year. All regulations as to fees are subject to change by the Trustees at their discretion.

For Matriculation or Registration: Required of all students before entrance, payable but once	$ 5
For late Registration (see above)	5
For Tuition in the Schools of Mines, Engineering and Chemistry, payable at the beginning of each half-year; if the entire fee be less than $100 the whole must be paid upon registration.	
For matriculated students for each half-year	$ 125
For non-matriculated students, at the rate of $25 per annum for each hour of attendance upon lectures and recitations per week, with certain additional charges for laboratory work; the whole not to exceed $250 per annum.	
For the use of the Gymnasium	7
For Examinations, payable in each case before the examination is held:	
For entrance (see p. 11 *et seq.*)	$ 5
For any examination or single series of examinations taken at any other time than at the conclusion of a course actually attended	5
For any professional degree	25

Laboratory Fees

Students not candidates for a degree, as well as all candidates for the higher degrees, are charged, in addition to the prescribed tuition fee, a fee for certain laboratory courses and for the use of laboratories, up to a maximum fee of $250, including tuition. The schedule of such fees may be obtained from the Registrar.

Summer Courses in Surveying

Laboratory fees, payable on or before the last Saturday in May, are required as follows: Civil Engineering course No. 15, $25, or $7 per survey; No. 25 and No. 27, $15, or $5 per survey; No. 26, $5; No. 28 and No. 71, $10.

Non-candidates, candidates for admission to, and students having entered with advanced standing, who may be required to attend these courses, and students required to repeat them through delinquency, are charged in addition tuition fees as follows: No. 15, $35; No. 25, No. 27, No. 28, and No. 71, $25; No. 26, $10. In the case of a student registered in Columbia College, who has paid an additional fee under the operation of this rule, an equitable credit will be made should he later complete the requirements for a professional degree.

Deposits for Apparatus Supplies and for Keys to Desks and Lockers

A deposit for the use of lockers, keys, apparatus, material, and the like, ranging from $1 to $40, is required of students in Mines, Engineering and Chemistry. At the end of the year each student will be credited with those articles which he returns in good order, and the value of those he has injured or broken will be deducted from his deposit. Details may be obtained from the Bursar.

Residence Halls and University Commons

(See page 123)

Scholarships

(See page 129)

Employment Committee

(See page 122)

Comparative Statement of Students' Probable Expenses for the Academic Year

	Low	Average	Liberal
Matriculation	$ 5	$ 5	$ 5
Gymnasium	7	7	7
Tuition	250	250	250
Books	30	45	60 up
Drafting material	2	10	15 "
Chemical apparatus	25	30	40 "
Room (37 weeks)	75	129	160 "
Board (37 weeks)	150	180	205 "
Clothes and laundry	25	40	75 "
College incidentals	2	5	25 "
Other expenses	10	25	75 "
SUMMER COURSES IN SURVEYING			
Tuition	25	25	25
Travelling	5	5	5 up
Board (5 weeks)	35	35	35 "
	$696	$833	$1052

The expense for summer courses in surveying applies to all curriculums during the first summer only; for Mining Engineers during two summers and Civil Engineering three summers.

RULES GOVERNING STUDENTS

1. A student cannot be a candidate for more than one professional degree at the same time.

2. A candidate for a degree must comply with all requirements in force at the time said degree is conferred.

3. A student will be permitted to substitute one subject for another provided he obtains the consent of the Dean, the heads of departments concerned and the head of the department giving the technical instruction leading to the degree.

4. A student absent from more than one-tenth of the required exercises will be debarred from examination in that subject. Exceptions may be made by the instructor for reasons of weight when the absences do not exceed one-fourth the total number of exercises.

5. After examinations have been held, officers shall send to the Registrar a list of all students who have attended their courses, indicating proficiency by numbers on a scale of 10, a mark below 6 signifying a failure to pass. Students' records will be sent to them by the Registrar at the close of each year.

6. A student who has failed in any subject shall not be permitted to take advanced studies for which such failure indicates a lack of necessary preparation.

7. Regular examinations may be held at the end of the 1st and 2nd term or both, or at the completion of any course.

8. Special examinations for students debarred or deficient at regular examinations shall be held during the two weeks in September preceding the opening of the next following academic year; and for members of the fourth class in subjects belonging to that year only, during the first week in May.

9. The fee for special examination is $5, which must be paid before admission to examinations. If a student have special examinations in several subjects (during the same examination period), only a single fee of $5 shall be paid.

10. A student failing to pass in any subject at the regular examinations must present himself for special examination as provided under 8.

Failing to pass the second examination, he must repeat the subject with the next class. Failing a third time to pass a satisfactory examination he shall be dropped from the roll of the School.

11. Absence from any regular or special examination provided for in Rules 7 and 8 shall count as a failure unless excused by the Dean for reasons of weight.

12. A student shall be enrolled in the class in which the majority of his hours are taken; provided, however, that no student shall be advanced from the first to the second class who has en-

trance conditions aggregating 2 points; no student shall be advanced to the third class who has any entrance conditions or any deficiencies of the first year; no student shall be advanced to the fourth class who has any deficiency.

13. Any student who shall have passed a satisfactory examination in Columbia College in any subject forming a part of one of the professional courses in the School of Applied Science will not be required to pursue that subject a second time.

14. During vacations following the close of each year, memoirs on assigned subjects must be prepared by students in the courses of Metallurgy, Civil Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering, and Chemistry. The time specified for the completion and handing in of memoirs is the first Monday in November.

A student failing to hand in his memoir, drawings or other summer work shall be considered to have failed; to have his work received later, he will be obliged to pay a fee of $5, as for a special examination.

15. By permission of the Dean, and concurrence of the heads of departments concerned, a student may attend subjects not required for his degree, provided such attendance does not interfere with his regular work. He must fulfill all the requirements exacted from regular students in such course.

OPPORTUNITIES FOR ADVANCED INSTRUCTION AND RESEARCH

Special attention is called to the opportunities offered through the Faculty of Pure Science to men who have received the Bachelor's degree or its equivalent from any recognized college or scientific school for advanced instruction and research in Mining Engineering, Metallurgy, Civil Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering and Chemistry, leading to the degrees of A.M. and Ph.D. Any of the subjects mentioned above may be offered as a major or minor for either of these degrees. An outline of the courses in these subjects which may be offered toward the higher degrees by candidates who have completed the necessary prerequisites will be found in this announcement (see pp. 48, 58, 70, 80, 99 and 105 *et seq.*), and the general regulations as to graduate work are printed in the pamphlet entitled "Instruction for Graduate Students," which may be had upon application to the Secretary of the University. Ordinarily, the degree of Master of Arts may be obtained after one year's work in residence and the degree of Doctor of Philosophy after three years, the minimum requirement for the latter degree, however, being two years.

UNIFORM CURRICULUM FOR THE FIRST YEAR

The curriculum for the first year of the four year courses leading to the degrees of Engineer of Mines, Metallurgical, Civil, Electrical, Mechanical and Chemical Engineer and Chemist is the same in every respect and the student entering the first year class need not declare which course he will follow until the beginning of the second year, when he will have the advantage of the experience gained during the first year's work, where uncertainty exists respecting inclination or natural bent.

As will be seen in the tabular statement given below this first year is mainly devoted to a thorough grounding in Mathematics, Physics and Chemistry, the three fundamental subjects which form the indispensible basis for all broad and successful engineering work, not only in the remaining years of the course, but throughout the entire professional career. Specialization begins to some extent in the second year and becomes more marked in the third and fourth years.

The class is arranged in two divisions, Division B completing Engineering Drafting and Descriptive Geometry in the first term while Division A is completing Qualitative Analysis, the two divisions reversing the operation in the second term. This plan secures greater concentration of work; it facilitates the transfer of students to advanced standing from other institutions; and it enables well prepared students entering in February and taking advantage of the University Summer Session to catch up with their class by the following autumn.

To secure the most effective individual instruction the class is also divided for quizzes and recitations into six, eight, and in some cases twelve sections.

		First Half Year	Hours per week	
See Page			Class	Lab'y
116	Mathematics 3	Analytical Geometry	3	
103	Chemistry 3	General Inorganic Chemistry	4	
117	Physics 3	Elementary Mechanics, Properties of Matter and Sound	5	
113	Drafting 1	Engineering Drafting	1	14
113	Drafting 3	Descriptive Geometry	3	
117	Phys. Educ. A	Gymnasium		2
		Total..	16	16
		Second Half Year		
115	Mathematics 2	Spherical Trigonometry	2	
116	Mathematics 4	Analytical Geometry	3	
103	Chemistry 4	General Inorganic Chemistry	3	
117	Physics 4	Light, Heat, Electricity and Magnetism	3	
106	Chemistry 62	Qualitative Analysis	4	13
64	Civil Eng 2	Theory of Surveying	2	
117	Phys. Educ. A	Gymnasium		2
		Total..	17	15

SUMMER WORK: Civil Eng. 15. Five weeks of surveying practice.

COURSE LEADING TO THE DEGREE OF ENGINEER OF MINES

The four-year course leading to the degree of Engineer of Mines is intended primarily to train men to undertake the development of mineral properties, the design and construction of mine plants, and to manage mines. The course includes training in metallurgy. It is necessarily a broad one, comprising a wide range of studies in pure and applied science, and for this reason is frequently taken by students desiring a general scientific training.

The subjects most emphasized in this course are mining, metallurgy, geology, and engineering.

Mining and metallurgy require knowledge of inorganic and applied chemistry, qualitative and quantitative analysis, and assaying.

Geology must carry with it preliminary training in crystallography, mineralogy, and petrography.

Engineering in all its branches needs a fundamental knowledge of mathematics, physics, mechanics, and thermodynamics. The proper design and construction of mining plants involves the study of certain branches of civil engineering, and the many and increasing applications of machinery to mining make it necessary to give much time to the theory and practice of mechanical and electrical engineering.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
116	Mathematics 5	Calculus	5	
108	Chemistry 81	Industrial Chemistry	3	
116	Mineralogy 1	Mineralogy	6	9
75	Elect. Eng. 1	Elements of Electrical Engineering	2	
65	Civil Eng. 23	Theory of Railroad Surveying	2	3
113	Eng. Drafting 7	Structural Drafting		3
117	Phys. Educ. B	Gymnasium		2
		Total..	18	17

		Second Half Year		
118	Mechanics 102	Analytical Mechanics	5	
108	Chemistry 82	Industrial Chemistry	3	
106	Chemistry 66	Quantitative Analysis	3	15
114	Geology 6	General Geology	6	
75	Elect. Eng. 2	Elements of the Dynamo	2	
117	Phys. Educ. B	Gymnasium		2
		Total..	19	17

SUMMER WORK: Civil Eng. 27 and 28, Practical Surveying (eight weeks).

THIRD YEAR

See Page		First Half Year	Hours per week Class	Lab'y
86	Mech. Eng. 17	Technical Thermodynamics	2	
67	Civil Eng. 53	Resistance of Materials	5	3
6	Civil Eng. 55	Testing Laboratory and Problems		3
114	Geology 105	Economic Geology	3	
44	Mining 51	Excavation and Tunneling	3	
86	Mech. Eng. 13	Steam Power Machinery	3	
108	Chemistry 69	Assaying	2	9
		Total..	18	15

		Second Half Year	Class	Lab'y
114	Geology 106	Economic Geology	3	
68	Civil Eng. 64	Graphic Statics	1	3
67	Civil Eng. 54	Resistance of Materials—problem work		3
86	Elect. Eng. 104	Electrical Distribution	2	
86	Mech. Eng. 14	Steam Power Machinery	3	
98	Mech. Eng. 76	Experimental Mechanical Engineering	1	3
98	Elect. Eng. 72	Direct Current Laboratory		3
44	Mining 52	Boring & Shaft Sinking (3 hrs. for 3 mos.)	2	
45	Mining 54	Methods of Mining	3	
116	Mineralogy 6	Optical Mineralogy (6 hrs. for 2 mos.)		3
114	Geology 4	Petrography (6 hrs. for 2 months)		3
	Metallurgy 1	Metallurgy of Copper	2	
		Total..	17	18

SUMMER WORK: Field work, Mining, Metallurgy, and Geology (8 to 10 weeks).

FOURTH YEAR

		First Half Year	Class	Lab'y
76	Elect. Eng. 75	Alternating Current Laboratory		3
55	Metallurgy 5a, 5b	Electro-Metallurgy and Iron and Steel	2	
5	Metallurgy 5	Metallurgy of Gold, Silver, etc.	3	
46	Mining 73	Mine Constructions	1	
45	Mining 71	Mine Plant	3	
46	Mining 75	Design of Mine Plant		12
47	Mining 91	Mine Administration and Accounts	2	
47	Mining 81	Ore Dressing	4	
115	Geology 201	Petrography (elective)		
		Total..	15	15

		Second Half Year	Class	Lab'y
115	Geology 110	Geological Surveys	2	
60	Civil Eng. 76	Hydraulics—(3 hrs. for 3 months)	2	
98	Mech. Eng. 74	Gas Power Machinery	2	
57	Metallurgy 72	Metallurgical Laboratory		2
45	Mining 56	Mine Engineering	3	
45	Mining 72	Mine Plant	3	
47	Mining 80	Mill Constructions	1	
47	Mining 94	Mining Law	2	
47	Mining 82	Ore Dressing (Lab.)—(afts. of 3 weeks)		3
45	Mining 72	Thesis		12
114	Geology 16	Paleontology (elective)		
		Total..	15	17

COURSE LEADING TO THE DEGREE OF METALLURGICAL ENGINEER

This course is intended primarily for those who expect to be metallurgists, and to begin their professional work in minor administrative places in metallurgical works, or in the metallographic, testing or chemical laboratories there; and secondarily for those who wish to carry into other activities a training in the scientific method of thought and work, and a general knowledge of chemistry, physics, etc. Besides thorough training in the fundamentals and the usual lectures and recitations, great stress is laid on giving (1) by laboratory work close familiarity with the difficult high temperature conditions of metallurgy; (2) skill in microscopy and pyrometry; and (3) training in methodical planning and execution and in the interpretation of evidence.

There are separate laboratories (1) for iron and steel, (2) for the other metals and electrometallurgy, and (3) for metallography. Twenty-two per cent. of the work is in chemistry; 22 per cent. in mathematics, physics, mineralogy, and geology; 30 per cent. in drawing, and civil, mechanical, and electrical engineering; 6 per cent. in mining; and 20 per cent. in metallurgy. An effort is made to interest students in actual industrial and scientific investigations of present importance made in the department. In the 6-weeks summer courses at metallurgical works the students study, describe, and explain processes, make dimensioned sketches of furnaces and mills, and estimate approximately costs, profits, etc.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
55, 56	Metallurgy 5a, 55a	Metallurgy of Iron and Steel	4	
116	Mathematics 5	Calculus	5	
108	Chemistry 81	Industrial Chemistry	3	6
116	Mineralogy 7	Mineralogy	6	
75	Elect. Eng. 1	Elements of Electrical Engineering	2	
117	Physics 43	Physical Laboratory		6
117	Phys. Educ. B.	Gymnasium		2
		Total..	20	14
		Second Half Year		
113	Eng. Draft 8	Structural Drafting		3
118	Mechanics 102	Analytical Mechanics	5	
108	Chemistry 82	Industrial Chemistry	3	
114	Geology 104	General Geology	6	
106	Chemistry 66	Quantitative Analysis	3	12
75	Elect. Eng. 2	Elements of the Dynamo	2	
117	Phys. Educ. B.	Gymnasium		2
		Total..	19	17

SUMMER COURSES: Surveying Practice 5 weeks (Civil Eng. 27). Iron and Steel Works visits 3 weeks (Met. 64).

THIRD YEAR

See Page		*First Half Year*	Hours per week Class	Lab'y
108	Chemistry 69	Assaying	2	9
57	Metallurgy 171	Metallurgical Laboratory		6
86	Mech. Eng. 17	Technical Thermodynamics	2	
67	Civil Eng. 53	Resistance of Materials	5	3
114	Geology 105	Economic Geology	3	
86	Mech. Eng. 13	Steam Power Machinery	3	
		Total..	15	18
		Second Half Year		
55, 56	Metallurgy 2 & 52	Metallurgy of Copper	3	
114	Geology 106	Economic Geology	3	
68	Civil Eng. 64	Graphic Statics	1	3
67	Civil Eng. 54 & 56	Resistance of Materials—Prob. & Lab. Work		6
81	Elect. Eng. 104	Electrical Distribution	2	
86	Mech. Eng. 14	Steam Power Machinery	3	
98	Mech. Eng. 76	Experimental Mech. Engineering	1	3
98	Mech. Eng. 72	Direct Current Laboratory		3
86	Mech. Eng. 18	Technical Thermodynamics	2	
45	Mining 54	Methods of Mining	3	
		Total..	18	15

SUMMER COURSES: Non-ferrous Works Visits 3 weeks (Met. 62). Geology Field Work 1 week (Geol 112).

FOURTH YEAR

		First Half Year		
55, 56	Metallurgy 3 & 53	Metallurgy of Lead, Gold, Silver, Zinc	4	
56	Metallurgy 57	Metallurgy of Alloys—3 hrs. for 10 wks.	2	
56, 55	Metal'gy 5b & 55b	Electro-metallurgy—3 hrs. for 5 wks.	1	
57	Metallurgy 175	Art of Met'g'l Invest'g'n—3 hrs. for 10 wks.		2
57	Metallurgy 77	Thesis		9
46	Mining 73	Mine Constructions	1	
47	Mining 81	Ore Dressing	4	
47	Mining 91	Mine Administration and Accounts	2	
103	Chemistry 121	Physical Chemistry	3	3
76	Elect Eng. 75	Alternating Current Laboratory		3
		Total..	17	17
		Second Half Year		
57	Metallurgy 78	Thesis		16
47	Mining 82	Ore Dressing—5 afts. for 3 weeks		3
47	Mining 94	Mining Law (or Law of Contracts)	2	
103	Chemistry 122	Physical Chemistry	3	
66	Civil Eng. 76	Hydraulics—2 hours	2	
98	Mech. Eng. 72	Gas Power Machinery	2	3
47	Mining 80	Mill Constructions	1	
55	Metallurgy 4 (part)	Metallurgy of Iron and Steel—10 lectures	1	
		Total..	11	22

COURSES LEADING TO THE DEGREE OF CIVIL ENGINEER

The courses of study given in the Department of Civil Engineering are so formulated as to constitute broad educational training of a professional character for students intending to follow the practice of Civil Engineering or such other affiliated callings as may be based more or less upon the various branches of Civil Engineering. These courses of study can be taken more advantageously if the student has had a preliminary general training equivalent to that of an ordinary college course although that condition is not a requisite. It is strongly urged that wherever practicable three years of study should be taken in Columbia College followed by three years of study in the Department of Civil Engineering, thus making a complete course of general and professional study of six years. Through these courses of study there is set forth a thorough grounding in the fundamental principles of engineering science as the first essential, supplemented, however, by constant exercises in the application of those fundamental principles to all the operations of the Civil Engineer, involving structures, machines and processes connected with the adaptation and transmission of power for industrial and other purposes.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
116	Mineralogy 5	Minerals of Building Stones	2	2
116	Math. 5	Differential and Integral Calculus	5	
86	Mech. Eng. 13	Steam Power Machinery	3	
75	Elect. Eng. 1	Electrical Engineering	2	
112	Botany 7	Growth and Character of Timbers	1	3
113	Drafting 5	Graphics		6
120	Shop Work	Wood Working		3
44	Mining 51	Excavation and Tunneling	3	
75	Civil Eng. 21	Roads, Streets and Pavements	2	
117	Phys. Educ. B	Gymnasium		2
		Total..	18	16
		Second Half Year		
114	Geology 18	General Geology	3	*3
118	Mechanics 102	Analytical Mechanics	5	
86	Mech. Eng. 14	Steam Power Machinery	3	
75	Elect. Eng. 2	Electrical Engineering	2	
55	Metallurgy 4	Iron and Steel	2	
117	Physics 44	Physics Laboratory		6
108	Chemistry 82	Industrial	3	
113	Drafting 8	Structural Drafting		6
120	Shop Work	Bench-work and Machine-work		3
117	Phys. Educ. B	Gymnasium		2
		Total..	18	18

*Saturday P.M., 1 afternoon during April and May—equivalent 1 hour.

SUMMER WORK: Practical Surveying Civil Eng. 25—5 weeks.

THIRD YEAR

See Page		*First Half Year*	Class	Lab'y
67	Civil Eng. 53	Resistance of Materials	5	3
67	Civil Eng. 55	Resistance of Materials Testing		3
67	Civil Eng. 51	Railroad Surveying	2	3
68	Civil Eng. 61	Theory of Trusses	2	3
66	Civil Eng. 59	Sanitary Treatment, Water Supply and Sewerage	2	
77	Elect. Eng. 101	Dynamo and Motor Practice	2	
76	Elect. Eng. 73	Direct Current Laboratory		3
86	Mech. Eng. 17	Technical Thermodynamics	2	
112	Astronomy 105	Geodesy	3	
		Total..	18	15

Hours per week

See Page		*Second Half Year*	Class	Lab'y
67	Civil Eng. 54	Resistance of Materials		3
67	Civil Eng. 52	Railroad Surveying	3	3
68	Civil Eng. 62	Graphic Statics	2	3
68	Civil Eng. 58	Masonry Structures	3	3
77	Elect. Eng. 104	Electrical Distribution	2	
86	Mech. Eng. 18	Technical Thermodynamics	2	
98	Mech. Eng. 76	Mechanical Laboratory	1	3
90	Mech. Eng. 36	Kinematics	3	
112	Astronomy 106	Geodesy	1	3
		Total..	17	18

SUMMER WORK: Hydrographic Surveying—Civil Eng. 26; Geodetic " —Astronomy 107 — 5 weeks.
Railroad surveying practice—Civil Eng. 71—4 weeks.

FOURTH YEAR

See Page		*First Half Year*	Class	Lab'y
69	Civil Eng. 85	Foundations	2	3
69	Civil Eng. 87	Bridges, Roofs and Buildings	2	3
66	Civil Eng. 75	Hydraulics	4	
96	Mech. Eng. 63	Hydraulics Laboratory		3
76	Elect. Eng. 75	Alternating Current Laboratory		3
91	Mech. Eng. 41	Machine Design	1	3
69	Civil Eng. 89	Railroad Engineering	3	3
70	Civil Eng. 95	Contracts and Specifications	2	
		Total..	14	18

See Page		*Second Half Year*	Class	Lab'y
69	Civil Eng. 88	Bridges, Roofs and Buildings	2	3
69	Civil Eng. 90	Railroad Engineering	3	3
70	Civil Eng. 98	Water Supply Eng. and Irrigation	2	
70	Civil Eng. 94	Design and Construction of Sewers; River and Harbor Improvement	2	
91	Mech. Eng. 46	Hydraulic Power Machinery	3	
78	Elect. Eng. 112	Electric Railway	2	
70	Civil Eng. 100	Thesis	3	9
		Total..	17	15

COURSE LEADING TO THE DEGREE OF ELECTRICAL ENGINEER

The objects for which the regular four years course in Electrical Engineering is designed and the education which it is intended to give are fully set forth in the "General Statement" of the Electrical Engineering Department, found on page 72.

The actual curriculum, including the various requirements which must be fulfilled in order to obtain the E. E. degree, are named in the following list of studies for each year, the character of each subject or requirement being explained more fully in the Departmental Statement referred to. The first two years of the course are devoted to the fundamental subjects, including mathematics, physics, chemistry, mechanics, drawing and certain electrical and mechanical engineering subjects which are elementary or introductory in character.

These fundamental and introductory subjects are intended to lay a broad and substantial foundation upon which the more specialized professional instruction of the third and fourth years is based. Even in these later years theoretical subjects, such as thermodynamics and electrical theory, are included and given most careful attention.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
106	Chemistry 65	Quantitative Analysis	2	6
108	Chemistry 81	Industrial Chemistry	3	
75	Elect. Eng. 1	Elements of Electrical Engineering	2	
116	Mathematics 5	Differential and Integral Calculus	5	
86	Mech. Eng. 13	Steam Power Machinery	3	
117	Physics 43	Physical Laboratory		6
117	Physics 105	Physics Measurements	2	
120	Shop Work	Carpentry and Pattern Work		3
111	Phys. Educ. B	Gymnasium		2
		Total..	17	17
		Second Half Year		
108	Chemistry 82	Industrial Chemistry	3	
113	Drafting 6	Graphics	1	6
113	Drafting 8	Structural and Machine Drawing		6
75	Elect. Eng. 2	Elements of the Dynamo	2	
55	Metallurgy 4	Metallurgy of Iron and Steel	2	
120	Shop Work	Bench and Machine Work		3
118	Mechanics 102	Analytical Mechanics	5	
86	Mech. Eng. 14	Steam Power Machinery	3	
117	Phys. Educ. B	Gymnasium		2
		Total..	16	17

Summer memoir.

THIRD YEAR

See Page		*First Half Year*	Hours per week Class	Lab'y
67	Civil Eng. 53	Resistance of Materials	5	3
	Civil Eng. 55	Testing Laboratory		3
77	Elect. Eng. 101	Dynamo and Motor Practice	2	
79	Elect. Eng. 173	Direct Current Laboratory		6
118	Mechanics 107	Theory of Dynamo and Motor	2	
118	Mechanics 105	Thermodynamics	2	
91	Mech. Eng. 41	Machine Design	1	3
86	Mech. Eng. 17	Technical Thermodynamics	2	
67	Civil Eng. 77	Hydraulics	2	
		Total..	16	15

See Page		*Second Half Year*	Class	Lab'y
67	Civil Eng. 54	Resistance of Materials		3
76	Elect. Eng. 52	Design of Direct Current Machinery	2	3
80	Elect. Eng. 104	Electrical Distribution	3	
78	Elect. Eng. 174	Direct Current Laboratory		3
90	Mech. Eng. 36	Kinematics of Machinery	3	3
98	Mech. Eng. 76	Experimental Mech. Eng.	1	3
118	Mechanics 108	Theory of Dynamo and Motor	3	
86	Mech. Eng. 18	Technical Thermodynamics	2	
	Economics 1	Economics	3	
		Total..	17	15

Summer memoir.

FOURTH YEAR

See Page		*First Half Year*	Class	Lab'y
104	Chemistry 37	Physical Chemistry	2	
110	Chemistry 183	Electrochemistry	2	6
77	Elect. Eng. 103	Electric Power	3	
78	Elect. Eng. 105	Electrical Plants	2	
80	Elect. Eng. 177	Instrument Laboratory	1	6
98	Mech. Eng. 77	Experimental Mechanical Laboratory	1	3
118	Mechanics 109	Theory of Alternators & Transformers	3	
92	Mech. Eng. 53	Steam Turbines	2	
		Total.	16	15

See Page		*Second Half Year*	Class	Lab'y
76	Elect. Eng. 54	Design of Alt. Current Machinery	2	
78	Elect. Eng. 106	Management of Electric Plants	2	
78	Elect. Eng. 112	Electric Railways	2	
79	Elect. Eng. 176	Alternating Current Laboratory	1	9
94	Mech. Eng. 56	Water Power Installations	1	
95	Mech. Eng. 60	Hydraulic Laboratory		3
118	Mechanics 110	Theory of Variable Currents	2	
	Elect. Eng. 98	Graduation Thesis (Optional)		3
98	Mech. Eng. 72	Gas Power Machinery	2	3
	Elect. Eng. ?	Preparation of Reports		3
78	Elect. Eng. 110	Telegraph and Telephone	2	
		Total..	14	18

COURSE LEADING TO THE DEGREE OF MECHANICAL ENGINEER

All the subjects leading to the degree of Mechanical Engineer are listed in the following table, together with the year and term in which they are given. The first two years are devoted to essential preparatory and fundamental subjects, mathematics, chemistry, physics, analytical mechanics and drawing which are co-ordinated with kinematics, elementary design, shop work and the elements of electrical and steam engineering. In the third year there are developed the basic principles of thermodynamics, resistance of materials and hydraulics, which are fixed in the mind of the student by drill in the drafting room by design courses, in the laboratory by experiments and tests and in class by analysis of standard mechanical and electrical machinery. The fourth year is devoted to a detailed treatment of gas and steam engine design, standard water turbine characteristics and the essential relations between units constituting power plants and factories. Special attention is here paid to the economics of mechanical engineering by courses in industrial law, economics and works management. Throughout the course the aim is to develop clear conceptions of underlying principles, habits of independent thought and orderly mental procedure applicable to any sort of Mechanical Engineering problems.

Because of the reorganization of the Department, the courses for 1908-1909 are given in detail.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
117	Physics 43	Physical Laboratory		6
75	Elect. Eng. 1	Elements of Electrical Engineering	2	
116	Mathematics 5	Calculus	5	
108	Chemistry 81	Industrial Chemistry	3	
94	Mech. Eng. 59	Empiric Design	2	3
113	Eng. Drafting 7	Structural Drafting		3
86	Mech. Eng. 11	Steam Power Machinery	3	
120	Shopwork	Pattern Making		6
117	Phys. Educ. B	Gymnasium		2
		Total..	15	20
		Second Half Year		
75	Elect. Eng. 2	Elements of Electrical Engineering	2	
118	Mechanics 102	Analytical Mechanics	5	
108	Chemistry 82	Industrial Chemistry	3	
90	Mech. Eng. 36	Kinematics		6
86	Mech. Eng. 12	Steam Power Machinery	3	3
120	Shopwork	Machine Shop		9
55	Metallurgy 4	Iron and Steel	2	
117	Phys. Educ. B	Gymnasium		2
		Total..	15	20

SECOND SUMMER: 125 hours in College shops; Mech. Eng. 94s. 6 weeks practical work in shops and drafting rooms of manufacturing establishments, with report. A total of 9 weeks.

THIRD YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
76	Elect. Eng. 73	Direct Current Laboratory		3
77	Elect. Eng. 101	Dynamo and Motor Practice	2	
89	Mech. Eng. 31	Mechanical Laboratory	1	3
67	Civil Eng. 53	Resistance of Materials	5	3
120	Shopwork	Metal Work		6
90	Mech. Eng. 39	Machine Design	1	6
118	Mechanics 105	Thermodynamics	2	
86	Mech. Eng. 17	Technical Thermodynamics	2	
		Total..	13	21

		Second Half Year		
77	Elect. Eng. 104	Electrical Plants	2	
95	Mech. Eng. 60	Hydraulic Laboratory	1	3
56	Metallurgy 58	Metallographic Laboratory		
67	Civil Eng. 78	Hydraulics	2	
	Civil Eng. 56	Materials Testing Laboratory		3
86	Mech. Eng. 18	Technical Thermodynamics	2	
89	Mech. Eng. 32	Mechanical Laboratory	1	3
93	Mech. Eng. 54	Principles of Machine Manufacture	2	
91	Mech. Eng. 40	Machine Design	2	6
97	Mech. Eng. 70, Pumping	Standard machinery for pumping, compressing, elevating and conveying, heating and cooling	6	
96	Mech. Eng. 64, Air Mach.			
96	Mech. Eng. 66, El. & Conv.			
95	Mech. Eng. 62, Refrig.			
		Total..	18	15

THIRD SUMMER: Mech. Eng. 96s. 6 weeks practical work in power plant, with report.

FOURTH YEAR

		First Half Year		
76	Elect. Eng. 75	Alternating Current Laboratory		3
77	Elect. Eng. 103	Electric Power	2	
78	Elect. Eng. 105	Electrical Distribution	2	
87	Mech. Eng. 19	Engine Design	6	12
89	Mech. Eng. 33	Mechanical Laboratory	2	3
92	Mech. Eng. 53	Steam Turbines	2	
95	Mech. Eng. 61	Seminar	1	
		Total..	15	18

		Second Half Year		
		Industrial Law	3	
	Economics 1	Economics	3	
87	Mech. Eng. 22	Gas Power Machinery	4	3
91	Mech. Eng. 46	Water Power Machinery	3	
97	Mech. Eng. 68	Manufacturing Plant Design	2	3
88	Mech. Eng. 26	Power Plant Design	3	6
92	Mech. Eng. 52	Works Management	2	
		Total..	20	12

COURSE LEADING TO THE DEGREE OF CHEMICAL ENGINEER

The regular four-year course of instruction shown below is designed primarily for the education of professional chemists who intend to devote their lives to the practice of this profession, either as teachers in colleges after pursuing further studies, or as research chemists, chemists or managers in manufacturing and other industrial enterprises.

The course in chemical engineering, as will be seen, is designed to educate chemists with a sufficient amount of engineering to fit them to take charge of chemical works which depend largely on the use of machinery. This requires a knowledge of mechanical engineering, electrical engineering, hydraulics, mechanical drawing, shopwork, etc., as well as a thorough knowledge of chemistry in all its branches. Such an education qualifies a man to act as manager of gas works, sugar refineries, dyeing and calico-printing establishments, electro-chemical works, etc.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
104	Chemistry 147	Organic Chemistry	2	
108	Chemistry 81	Industrial Chemistry	3	
106	Chemistry 163	Quantitative Analysis	4	9
75	Elect. Eng. 1	Elements of Electrical Engineering	2	
113	Eng. Drafting 7	Structural Drafting		6
117	Mineralogy 15	Determinative Mineralogy		3
116	Mathematics 5	Differential Integral Calculus	5	
117	Phys. Educ. B	Gymnasium		2
		Total..	16	20
		Second Half Year		
104	Chemistry 148	Organic Chemistry	2	
108	Chemistry 82	Industrial Chemistry	3	
106	Chemistry 164	Quantitative Analysis	4	15
75	Elect. Eng. 2	Elements of the Dynamo	2	
117	Mineralogy 16	Determinative Mineralogy		3
118	Mechanics 102	Analytical Mechanics	5	
117	Phys. Educ. B	Gymnasium		2
		Total..	16	20

SUMMER WORK: Chemistry 80a, Chemistry s42. Shopwork, 3 weeks in June.

THIRD YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
109	Chemistry 83	Industrial Chemistry	3	
107	Chemistry 171	Organic and Sanitary Analysis	4	9
85	Mech. Eng. 13	Steam Power Machinery	3	
94	Mech. Eng. 59	Empiric Design	2	3
55	Metallurgy 5b	Electro-metallurgy and Fuels (part term)	2	
67	Civil Eng. 53	Resistance of Materials	5	3
		Total..	19	15

		Second Half Year		
109	Chemistry 84	Industrial Chemistry	3	
108	Chemistry 170	Assaying	2	9
97	Mech. Eng. 70	Pumps and Pumping Machinery	2	
	Civil Eng. 56	Testing Laboratory		3
77	Elect. Eng. 104	Electrical Distribution	2	
76	Elect. Eng. 72	Direct Current Laboratory		3
55	Metallurgy 4	Iron and Steel	2	
85	Mech. Eng. 14	Steam Power Machinery	3	
		Total..	14	15

SUMMER WORK: Mech. Eng. 95s. Chemistry 80b. Chemical Factory work with Memoir—6 weeks.

FOURTH YEAR

		First Half Year	Hours per week	
109	Chemistry 85	Industrial Chemistry	3	
103	Chemistry 121	Physical Chemistry	3	2
110	Chemistry 97	Factory Apparatus and Machinery	3	
109	Chemistry 89	Industrial Laboratory		3
67	Civil Eng. 77	Hydraulics	2	
86	Mech. Eng. 17	Technical Thermodynamics	2	
98	Mech. Eng. 77	Experimental Engineering Laboratory	1	3
90	Mech. Eng. 39	Machine Design	1	6
			15	14

		Second Half Year		
109	Chemistry 86	Industrial Chemistry	3	
103	Chemistry 122	Physical Chemistry	3	
110	Chemistry 184	Practical Electro-Chemistry	2	3
110	Chemistry 98	Cost of Chem. Operations in Factories	3	
86	Mech. Eng. 18	Technical Thermodynamics	2	
98	Mech. Eng. 76	Experimental Engineering Laboratory	1	3
57	Metallurgy 72	Laboratory		2
	Chemistry 190	Thesis		9
			14	17

COURSE LEADING TO THE DEGREE OF CHEMIST

The regular four year course of instruction shown below is designed for the education of professional chemists who intend to devote their lives to the practice of this profession, either as teachers in colleges and scientific schools, after further preparation, or as chemists or research chemists in manufacturing and other industrial enterprises.

The course in chemistry includes not only all branches of theoretical, analytical, and industrial chemistry, but also collateral sciences, such as mathematics, mechanics, physics, mineralogy, metallurgy, mechanical and electrical engineering, and drawing, which have been found by experience to be required by the professional chemist. It is the intention to provide the graduate not only with a thorough knowledge of the principles and practice of chemistry in all its branches, but with such a broad and liberal education in the collateral sciences as will prepare him for every demand that will be likely to be made upon him in connection with his profession or in the pursuit of investigation.

First year, see page 21

SECOND YEAR

		First Half Year	Hours per week	
See Page			Class	Lab'y
103	Chemistry 21	Elementary Physical Chemistry		3
104	Chemistry 147	Elementary Organic—Lecture Course	2	
108	Chemistry 81	Industrial Chemistry—General Course	3	
106	Chemistry 163	Quantitative Analysis	4	12
175	Elect. Eng. 1	Elements of Electrical Engineering	2	
117	Mineralogy 15	Determinative Mineralogy		3
116	Mathematics 5	Differential and Integral Calculus	5	
117	Phys. Educ. B	Gymnasium		2
		Total..	16	20
		Second Half Year		
103	Chemistry 22	Elementary Physical Chemistry	3	2
104	Chemistry 148	Elementary Organic—Lecture Course	2	
108	Chemistry 82	Industrial Chemistry—General Course	3	
106	Chemistry 164	Quantitative Analysis	4	12
75	Elect. Eng. 2	Elements of Dynamo	2	
102	Mechanics 6	Analytical Mechanics (Briefer Course)	3	
116	Mineralogy 16	Determinative Mineralogy		3
117	Phys. Educ. B	Gymnasium		[illegible]
		Total..	17	19

SUMMER WORK: Chemistry 80a—Memoir.

THIRD YEAR

See Page		*First Half Year*	Class	Lab'y
			Hours per week	
109	Chemistry 83	Industrial Chemistry	3	
110	Chemistry 91	Chemical Microscopy		4
103	Chemistry 101	Advanced Inorganic	2	
107	Chemistry 171	Quantitative Analysis, Organic, Sanit'y	4	15
110	Chemistry 183	Industrial Electrochemistry	1	2
	Metallurgy 1	Metallurgy of Copper	2	
55	Metallurgy 5b	Electro-metallurgy and Fuels	2	
		Total..	14	21

See Page		*Second Half Year*	Class	Lab'y
109	Chemistry 84	Industrial Chemistry	3	
109	Chemistry 88	Industrial—Laboratory Course		6
110	Chemistry 92	Chemical Microscopy		4
103	Chemistry 102	Advanced Inorganic Chemistry	2	
108	Chemistry 170	Assaying	2	9
110	Chemistry 184	Industrial Electrochemistry	1	3
		Total..	8	22

SUMMER WORK: Chemistry 80b—Memoir.

FOURTH YEAR

See Page		*First Half Year*	Class	Lab'y
109	Chemistry 85	Industrial Chemistry	3	
109	Chemistry 89	Industrial Chemistry—Lab. Practice		3
103	Chemistry 121	Physical Chemistry	3	2
105	Chemistry 141	Organic Chemistry—General Course	5	12
103	Chemistry 7	Inorganic Chemistry—or		
104	Chemistry 23	Physical Chemistry—or		
110	Chemistry 93	Electro Chemistry—or		
105	Chemistry 143	Organic Chemistry—or } Elective or taken from after-noons	(2)	
106	Chemistry 167	Adv.Inorg.Anal.Chem.—or		
107	Chemistry 173	Adv. Org. Anal. Chem.—or		
110	Chemistry 95	Industrial Chemistry		
55	Mech. Eng. 13	Steam Power Machinery	3	
	Metallurgy 3	Lead, Gold, Silver and Zinc	3	
		Total..	17	17

See Page		*Second Half Year*	Class	Lab'y
110	Chemistry 86	Industrial Chemistry	3	
103	Chemistry 122	Physical Chemistry	3	
105	Chemistry 142	Organic Chemistry—General Course	5	
85	Mech. Eng. 14	Steam Power Machinery	3	
53	Metallurgy 4	Metallurgy of Iron and Steel	2	
103	*Thesis—*		2	15
104	Chemistry 8	Inorg Chemistry—or		
110	Chemistry 24	Physical Chemistry—or		
110	Chemistry 94	Electro-Chemistry—or		
105	Chemistry 96	Industrial Chemistry—or		
106	Chemistry 144	Organic Chemistry—or		
107	Chemistry 168	Adv. Inorg. Anal. Chemistry—or		
107	Chemistry 174	Adv. Org. Anal. Chemistry—or		
	Chemistry 176	Food Chemistry		
		Total..	18	15

MINING ENGINEERING

Officers of the Department of Mining

Henry S. Munroe, E.M., Ph.D., Sc.D. .... *Professor of Mining*
Robert Peele, E.M. .... *Professor of Mining*
Edward L. Kurtz, E.M. .... *Adjunct Professor of Mining*
Walter R. Crane, Ph.D. .... *Instructor in Mining*

For tabular statement of program of studies, see pages 21 and 22.

General Statement

The instruction in the School of Mines during the first and second years includes the necessary fundamental training in mathematics, physics, mechanics, chemistry, mineralogy, and geology outlined in the program of studies on page 22. Surveying and engineering drafting begin with the first year.

The chemical laboratories for qualitative and quantitative analysis and assaying, the mineralogical and geological laboratories, the physical laboratories, and the drafting rooms are among the best in the country. Laboratory instruction in chemistry, assaying, drafting, mineralogy and geology extends through three years, the latter including microscopic work on thin sections of minerals and rocks.

In the engineering, mining, and metallurgical laboratories the student continues the work begun in the chemical and physical laboratories, and is given opportunity for the experimental demonstration of the physical, mechanical or chemical laws and general fundamental principles underlying any given branch of engineering. These laboratories are also equipped to train the student in the making of scientific tests of engineering materials, and working tests of machines and processes of ore treatment; thus preparing him, as far as it is possible in the school, for work that he will be called upon to do as an engineer. In the fourth year provision is made for several elective courses in Geology, for students who may be able to undertake extra work in certain parts of this subject which are not included in the requirements for the degree.

Practical instruction in summer classes in the field is made an important feature of the curriculum. Details of the summer courses in mining, metallurgy, field geology and surveying will be found on pages 41-43.

While much time is thus given to practical training in the labora-

tories, in the field, and at the mines and metallurgical establishments, care is taken to subordinate this instruction to the regular classroom work, and especially in subjects which are fundamental. In all such subjects a high standard of accomplishment is rigorously maintained. The courses are severe, and should be undertaken only by those who are well prepared physically, mentally, and by previous training to devote themselves earnestly to the work required of them.

Advanced Students and Graduates can choose their subject and plan of work much more freely than undergraduates, and provided they work with foresight they gain by relying chiefly on their own resources.

Situation of the School of Mines

Many coal, iron, and other mines, together with quarries and metallurgical works, are easily accessible from New York in from one to four hours by rail. Among these are magnetic iron mines in New York, New Jersey, and Pennsylvania; hematite mines and stone quarries in the same states, and in Connecticut; anthracite and bituminous coal mines, and natural gas and oil wells in Pennsylvania, and zinc mines in New Jersey and Pennsylvania. New York and the adjacent states produce each year about half the pig-iron and coal, and over forty per cent. of the total value of the mineral product of the whole country. There are within easy reach of New York City iron blast furnaces and some of the most skilfully arranged and managed steel works, rolling mills, steel and iron foundries, copper smelting and refining works, lead refining works, zinc works, and electrolytic establishments in the world. New York City, moreover, is the headquarters of many corporations operating mines and metallurgical works in this and other countries. Within a radius of one hundred miles may be studied many phases of the best practice in mining and metallurgy in the country. By going a little farther one may reach the bituminous coal fields and the natural gas, oil and salt regions in one direction, and the pyrite deposits, and granite and marble quarries of New York and New England in the other; while the excursions of the summer class in mining extend as far as the copper, iron, zinc, lead, silver, and gold regions of Michigan, Missouri, Montana, Colorado, California, Arizona and Utah.

Building

The School of Mines Building—Through the generosity of Mr. Adolph Lewisohn a new building was given in 1905 for the School of Mines for the use of the departments of mining and metallurgy. The School of Mines building is 145 feet long by 57 feet in width and four stories in height, with basement and sub-basement, or six floors in all. The basement and sub-basement contain the ore-dressing labora-

tories. In the center of the building on the main floor, and on either side of the entrance hall, are the mining and metallurgical museums. At the north and south ends of the building are the lecture rooms, opening out of the museums. On the second floor are the offices of the department of mining, the mining and metallurgical department libraries, a drafting-room for the design work of the fourth year, and one of the metallurgical laboratories. On the third floor are the offices of the department of metallurgy, the furnace rooms, the chemical laboratory, metallographic laboratory, and the research laboratories of the same department.

EQUIPMENT

Lecture Illustrations—The lectures on mining are illustrated by 5 sets of books aggregating over 300 volumes, and containing 85,000 blue prints from negatives made for the purpose. There are a sufficient number of these books, illustrating the different courses of lectures, to allow each student the use of one or more for reference during the lectures, and for home study. These blue prints have many advantages over the usual form of lecture illustrations by lantern slides or wall diagrams. The latter are, however, used when necessary to supplement the blue prints.

Mining Library—The University library contains complete sets of the transactions of all mining, metallurgical, and engineering societies, and of the more important periodical publications on these subjects. There is also a large collection of books on mining, and all new publications of value are added as they appear. In addition, a small departmental library has been created, which is accessible to students at all times.

Mining Museum—The subject of mining is illustrated by collections, as follows: Maps of coal and metal mines of this and other countries. Working drawings, diagrams, and photographs of mine plant, and of mining and dressing machinery. Models of mines and parts of mines, and of mine plant. Mining tools: picks, shovels, hammers, drills, blasting apparatus, lamps, safety-lamps, anemometers, hand-power and machine drills. Ores and dressing products from typical works in this and other countries. Surveying instruments: geological compasses and clinometers, attraction compasses, dipping needles, hanging compasses and arcs, transits, lamp signals, rods, and apparatus for plumbing and measuring shafts.

Among the more notable exhibits are large relief models of two mines of the Cleveland-Cliffs Iron Mining Co. of Michigan, a similar model of a typical gold mine in Colorado, and a set of three glass models and two relief models of the Copper Queen Mine in Arizona, a model of the mine workings in the Mahonoy and Shenandoah anthracite coal basins, Pennsylvania, a glass model of the mine workings on

the Calumet Conglomerate of Houghton County, Michigan, a model of a standard oil-well drilling rig, and a model of the St. Joseph Lead Co.'s dressing works at Bonne Terre, Missouri.

A collection of working drawings of mine plant, and a large collection of underground photographs, taken by magnesium light, are worthy of special notice.

MINING LABORATORIES—Seven rooms in the basement and sub-basement of the School of Mines Building are equipped as laboratories for the department of mining. These laboratories serve to supplement the study of ore concentration and milling made by the student as a part of the work of the Summer School of Mining, and afford him facilities for such study that cannot well be given him at the works. They include the following:

THE LABORATORY FOR MECHANICAL ASSAYS contains appliances for quantitative work in hand picking, jigging and vanning small samples of ore, and for panning gold-bearing gravel. For small scale working tests there are a number of specially designed laboratory classifiers, laboratory jigs, and laboratory slime tables.

THE CRUSHING AND SAMPLING LABORATORY contains machinery for crushing and sampling large and small lots of ore, including gyratory and jaw crushers, rolls, a sample grinder, ball and pebble mills for fine crushing, gyratory screens, automatic samplers, and laboratory crushers, together with sieves, riffle samplers, etc.

THE LABORATORY FOR WORKING TESTS contains a small vanning jig, an air jig, a buddle, a keeve, magnetic and electrostatic separators, and other similar apparatus for working a ton or more of ore at a time.

THE LABORATORY OF DRESSING MACHINERY contains full-sized machines of standard types, each arranged so that the products, heads, middlings and tailings are returned at once to the same machine for re-treatment. With a small quantity of ore each machine can thus be operated as long as may be necessary, and the student is afforded an opportunity to become familiar with the adjustments of the machine and the tests of proper and successful working. The apparatus now installed includes three Harz jigs of two, three and five compartments, two round tables, concave and convex, a Frue vanner, a Wilfley table, and a Stein-Bilharz belt table. On the floor below are full-sized classifiers, dewatering cones, automatic feeders, and centrifugal pumps for supplying these machines with water and ore for continuous work.

Mining Laboratory Instruction

The work required in the mining laboratories is designed (1) to illustrate the physical laws and practical conditions affecting the mechanical concentration, separation, and purification of minerals; (2) to instruct the students in the details of quantitative working tests on

both small and large scale; (3) to train them in the adjustment and operation of the standard types of concentrating machines, and in testing the efficiency of such machinery in actual operation, and (4) to give opportunity for original research.

The work includes the reduction of a ton or more of ore to laboratory samples, and tests on portions of this ore by handpicking, hand jigging, and mechanical treatment on laboratory jigs, classifiers, and slime tables, to determine the proper method of mill treatment. These tests are controlled by crushing and vanning samples of the products, and reports of the results obtained are made in a systematic manner.

The large concentrators are arranged to be run continuously, for as many hours as may be necessary, using the same ore and the same water again and again. This is accomplished by running the products of the several machines through dewatering cones, from which the mixed material is transferred to the hoppers of automatic feeders. Variable speed pulleys permit any desired adjustment of the driving mechanisms. The water supply is drawn from a constant level tank fed by a centrifugal pump, and is regulated by dial cocks. Other adjustments are equally under control and can be varied at will.

With each of these machines the student makes a series of experiments designed to bring out the physical laws governing successful working, to afford instruction in the practical details of operating the machines, and to give opportunity for engineering tests of capacity and efficiency under different conditions of treatment. These include the adjustment and regulation of the ore supply, of the feed and wash water, of speed, stroke, and other working conditions to the treatment of different ores and different grades of sand and pulp. In this work the student is taught to recognize the symptoms of irregular working, to diagnose the trouble with the aid of laboratory tests, and to apply the proper remedy. Incidentally he makes tests of capacity and efficiency, taking frequent samples of the ore feed, and of the different products for quantitative examination, and weighs and measures the ore and water supply and products obtained.

Experiments of this kind for purposes of instruction cannot well be made at concentration works in the field. Here the machines must work regularly and without interruption, and any interference with the ore feed, water supply, or other adjustments may occasion loss of valuable mineral.

Research Work—The equipment of the mining laboratories includes necessary facilities for original investigation in the physical laws controlling the mechanical treatment of minerals.

The following titles indicate some of the lines of original research undertaken by graduate students in recent years:

Investigation of magnetic fields with reference to ore-concentration.

The effect of variations in the speed of crushing machinery on the production of undersized material. The amalgamation of gold ores. An investigation of the laws of jigging. The physics of ore-flotation.

Mining Thesis

The subjects for the graduation theses are assigned in the spring and summer preceding the final year of the mining course, and are made a part of the regular course of instruction. The subject given in each case is the problem of the opening and development of a mine, which is supposed to be located in some well-known mining district, and for which certain definite conditions as to size and character of ore body, amount of water to be pumped, and quantity of ore to be mined, are assumed. During the summer the student visits the assigned region and studies the conditions under which mining is there conducted, thus obtaining data for his thesis work. The information thus acquired is supplemented by study of the books and technical literature dealing with the subject. During the fourth year he decides upon the proper methods for opening, developing, and working the property; and makes estimates of the plant, machinery and capital required, the cost of working, and the probable profits. He is also required to work out in detail certain portions of the proposed mine plant, and to prepare a set of working drawings, bills of materials and specifications therefor. This work and the preparation of the thesis is done under the supervision of competent instructors, and constitutes both a review and a series of practical applications of the preparatory studies of previous years. It enables the students to discover and remedy their deficiencies and gives them some degree of confidence in their ability to work out similar problems later.

SUMMER COURSES

Summer Courses in Surveying—These courses are conducted during thirteen weeks of the summer vacations at a large farm owned by the University near Litchfield, Conn. About five weeks attendance is required of each class between the first and second years, and eight weeks between the second and third years. A fuller statement with regard to this work will be found on page 61.

Summer Courses in Practical Mining—The scheme of instruction includes six to eight weeks spent in detailed study of the plant and methods of working at some mine or mines; in geological work, surface and underground; in mine surveying, and in excursions to other mines and mining regions. These summer courses are under the supervision of one of the Professors of Mining and the other members of the staff of the Department of Mining. The course of study includes shaft-sinking, drifting, stoping, timbering, underground haulage, hoist-

ing, mine drainage, ventilation, surface plant, mine buildings, repair shops, houses, etc., water supply, organization, administration, and underground surveying. The students are divided into small squads, and assigned each day to a foreman, or working gang of miners, for the study of some definite subject. Each squad of students is visited several times during the day by the instructor, who examines their work and indicates subjects demanding special study and observation. Manual labor and the acquirement of manual dexterity by the student are subordinated to the development of his powers of observation, and to the careful study of the work going on about him, and the recording of his observations and study in notes and sketches taken on the spot. The students' note-books are examined and criticised each evening. By thus systematizing and directing the work of the student his time is economized, and the work done more thoroughly. Arrangements are also made at other mines, by which the students, singly or in small groups, may substitute for the class-work described above independent study, according to a definite plan and under the general direction of the department.

These summer courses have been in operation since 1877, and have proved themselves an indispensable adjunct to the regular curriculum. They bear the same relation to the study of mining as laboratory work to the study of chemistry or physics, or clinical instruction and hospital practice to the study of medicine.

In 1905, the summer session was held at the Richard, Hurd and Mount Hope iron mines, near Dover, N. J., and the Maltby, Prospect, Drifton, Oneida and other collieries, in the anthracite fields. The larger part of the class was sent out in separate squads, without instructors, to certain gold, silver, copper and iron mines, chiefly in the West, at which arrangements were previously made and the necessary privileges secured. Among these mines were the Daly West, Utah; Baltic and Aragon, Michigan; Camp Bird, Colorado, and the properties of the Tennessee Copper Co. and the Copper Queen and Arizona Copper Co., of Arizona.

In 1906, a small division of the class studied in the mines of the Michigan copper region. The detail work, occupying four weeks, was done in the Wolverine mine. Short visits were then made to the Mohawk and Trimountain copper mines, and the surface plants of mines in the vicinity. The last week was spent at several iron mines of the Marquette district. As in 1905, the greater part of the class was distributed in small parties for study at a number of mines in the West, among which may be named the North Star, California, the Independence, Colorado, and the Bunker Hill and Sullivan, Idaho.

In 1907, the class was distributed in small squads at gold, silver, copper and iron mines in Michigan, Minnesota, Montana, Colorado,

Arizona and British Columbia. The time occupied was from 7 to 10 weeks. Several members of the class obtained positions at mines for the entire summer.

SUMMER COURSES IN METALLURGY—There are two courses, Nos. 62 and 64, which consist of studying and reporting on industrial processes at metallurgical works. The students receive individual and class instruction, and have to make complete descriptions of the processes, with dimensioned sketches of furnaces and other apparatus. Course 62 has to do with copper, lead, gold, silver and zinc works, and is compulsory for one week for students in mining engineering and for three weeks for students in metallurgical engineering. Course 64 has to do with iron and steel works, and is optional for one week for students in mechanical engineering and compulsory for three weeks for students in metallurgical engineering. The latter students may, under certain restrictions, replace two weeks of each of these two courses with actual employment in metallurgical works. In this case they must report on their experience, with full descriptions of processes and apparatus, and with analyses or dimensioned drawings of both. The visits to iron and steel works are generally made in Pennsylvania; those to non-ferrous works are sometimes in the west—sometimes in the east.

In 1905 and 1906 the non-ferrous summer class visited copper, lead, gold, silver and zinc works in the vicinity of New York City. The work in iron and steel was performed at several iron and steel works in the vicinity of Pittsburg in 1905. In 1907 students in metallurgy visited more than twenty iron and steel plants near Pittsburg.

In addition to these courses the students visit several iron and steel works in the neighbourhood of New York during the Easter vacation. This visit is optional for all students who are taking, or have taken, Metallurgy 5A or 4.

SUMMER COURSES IN GEOLOGY—In connection with the summer courses in practical mining, at least one week is devoted to practical field geology. The class is instructed in methods of field observation, locating outcrops, measuring dip and strike, keeping notes, etc., and afterwards are required to construct maps and geological sections from the observations noted. This instruction is given under the immediate supervision of the Professor of Geology.

METALLURGICAL AND OTHER EXCURSIONS—During the term the students are taken to various metallurgical establishments, and may visit mines, foundries, machine shops, electrical establishments, and points of geological interest in the city and its environs. Excursions for this purpose are frequently organized by the different departments.

In the regular SUMMER SESSION held at the University in July and August of each year many courses of interest to engineering students are offered. The *Announcement of the Summer Session* will be sent upon application to the Secretary of the University.

Other Departments

Information as to instruction and the equipment available for students of Mining and Metallurgy in other departments of the University is to be found in this pamphlet as follows:

COURSES IN MINING

Undergraduate Courses

51—Excavation and Tunneling—3 hours, first half third year. Professor Peele

Excavation of earth: tools and methods employed, support of excavations, special methods for quicksand and other water-bearing material; steam shovels and other mechanical excavators; handling and transportation of excavated material; comparative costs. Explosives: black powder, nitro-glycerine and its compounds, and other high explosives; their composition, manufacture, and use. Excavation of rock: methods of drilling and blasting, mammoth blasts, submarine blasting. Quarrying: plant and methods for quarrying different rocks. Railroad tunnels: methods of driving and timbering; handling and transportation of excavated material; drainage and ventilation; lining of tunnels; submarine tunnels. Mine tunnels; examples from practice; sizes, details of driving, timbering, rates of advance and costs.

Required of students in the courses of Mining and Civil Engineering

Pre-requisites: Entrance requirements in Mathematics, Chemistry, and Physics

52—Boring and Shaft Sinking—3 hours in Feb., March and April, third year. Professor Peele

Boring: methods and appliances for small depths and for deep boring; rod boring and cable tool or oil-well method; boring with diamond drill, for prospecting and other purposes; survey of bore-holes. Shaft sinking: methods and tools employed in soft material and in rock; sinking linings or drop-shafts, freezing and other special methods of sinking in water-bearing formations and quicksand; drainage of shafts;

handling and hoisting of excavated material. Shaft timbering, walling, tubbing, and other forms of lining.

Required of students in the courses of Mining and Civil Engineering
Pre-requisite: Mining **51**

54—Exploration, Development, and Methods of Working—3 hours, second half third year. Professor Munroe

Mineral deposits, characteristics of beds, masses, veins, and other deposits, and the irregularities and disturbances to which they are subject, as affecting the work of exploration and mining. Examination and survey of mineral properties; relation of topography to geological structure; construction of maps and sections; and tracing of probable outcrops as a guide to exploration. Prospecting by ditches, pits, and deep boring. Development; choice of methods; location of openings. Working of deposits and support of excavations; theoretical considerations, methods of breaking ground in coal and metal mining, and support of mine excavations by pillars of mineral, by timbering, by masonry, and by rock filling; methods of working applicable to deposits of different thickness, inclination, and character. Coal mining; vein mining; working of thick deposits and soft-ore bodies. Salt mining. Surface workings. Hydraulic mining and gold dredging.

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisites: Geology **5-6**. Pre-requisites or parallels: Geology **105-106**, Mining **51** and **52**

Counts, together with Mining **81** and **82**, or with Mining **56**, **55**, and **91**, as a minor for the degree of A.M.

56—Mine Engineering—3 hours second half fourth year. Professor Munroe

Ventilation; air of mines; mine gases; methods of ventilation; control and measurement of air currents. Drainage: sources of mine waters; methods for the control and raising of water; dams; drainage levels. Water supply. Surface handling and transportation; arrangements for loading and unloading cars and vessels, and for storing of minerals. Mineral railroads. Common roads. Accidents to men in shafts, levels and working places; fire-damp and dust explosions; mine fires; inundations; rescue and relief of men. Mine surveying, mine maps and models. Examination, sampling and valuation of mines

Required of students in the course of Mining Engineering
Pre-requisites or parallels: Mining **54** and **71-72**, Civil Engineering **76** and **28**
Counts, together with Mining **54** and **91**, as a minor for the degree of A.M.

71-72—Mine Plant—3 hours, fourth year. Professor Peele

Descriptions and critical discussion of the machinery and appliances employed in the equipment of mines; design, erection and care of plant. Hoisting: engines, drums, wire rope, skips and cages, head-frames; calculation of power required and methods of equalizing the load on the engine; shaft-sinking plant, over-winding. Drainage: buckets, tanks

and hand-pumps; Cornish and direct-acting underground pumps; operation of pumps by electricity, compressed air, and hydraulic power. Centrifugal pumps. Ventilation: natural ventilation, underground furnaces, positive blowers, and centrifugal fans; theory and efficiencies of fans. Air compressors: straight-line and duplex; simple and compound (stage) compression; methods of dealing with heat of compression; conveyance of compressed air in pipes; reheating; operation of machinery by compressed air; efficiencies. Machine drills: their construction and operation. Coal-mining machines or coal-cutters. Handling mineral in working places. Mine cars: arrangement and construction of tracks. Underground haulage; hand tramming; mule haulage; gravity roads; steam, compressed-air, and electric locomotives; rope haulage; efficiencies; comparison of systems of haulage

Required of students in the course of Mining Engineering

Pre-requisites: Mining **51**, **52** and **54**, and Mechanical Engineering **13**. Parallels: Mechanical Engineering **11**

Counts, together with Mining **73** and **75**, as a minor for the degree of A.M.

73—MINE CONSTRUCTIONS—1 hour, first half fourth year. Professor PEELE

Building-stones; bricks; limes; cements and concretes. Foundations in various soils; retaining walls; masonry and timber construction, with special reference to mine work; mine buildings; trestles; ore-bins

Required of students in the courses of Mining and Metallurgical Engineering

Counts, together with Mining **71-72** and **75**, or with Mining **81**, **82** and **75**, as a minor for the degree of A.M.

75—DESIGN OF MINE PLANT—4 afternoons first half fourth year. Professor PEELE, Professor KURTZ and Dr. CRANE

The students are assigned problems in the design and construction of mine plant, in connection with the development of a mine. This work supplements the lectures on the design of mining machinery, involving reading and study, and the preparation of working drawings, covering certain portions of the plant, together with bills of material, specifications, and estimates. As these drawings are intended to accompany and illustrate in part the graduating theses or projects, the designs are made in accordance with the subjects and conditions assigned to each student. The work is done under constant supervision and advice in the draughting-room

Required of students in the course of Mining Engineering

Pre-requisites: Mechanical Engineering **3-4**, **7-8**, Civil Engineering **53**. Parallel: Mining **71-72**

Counts, together with Mining **71-72** and **73**, or with Mining **81**, **82** and **73**, as a minor for the degree of A.M.

77-78—GRADUATING THESIS OR PROJECT—Professor PEELE

Required of students in the course of Mining Engineering

Pre-requisites or parallel: All the required courses in Mining

80—Mill Constructions—Installation and operation of mechanical power transmission and auxiliary machinery in works for the mechanical treatment of minerals. Dealing with shafting, bearings, pulleys, belting, rope drives, gearing, etc. 1 hour, second half fourth year. Professor Kurtz

Pre-requisite: Mechanical Engineering **13**

81—Ore Dressing, Milling, and the Mechanical Preparation of Coal—4 hours, first half, fourth year. Professor Munroe

The general principles and theory of dressing; preliminary operations; hand dressing; cleansing; crushing; jigging with and without preliminary sizing; slime concentration; magnetic and electro-static separation; oil and flotation processes; milling of gold and silver ores; descriptions of typical dressing works and coal-washing plants in this country and abroad.

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisites: Mineralogy **1-2**, Physics **3-4**. Pre-requisite or parallel: Mechanics **102**

Counts, together with Mining **54** and **82**, or with Mining **82**, **73** and **75**, as a minor for the degree of A.M.

82—Ore-dressing Laboratory—Afternoon work for three weeks, second half fourth year. Dr. Crane

Mechanical testing of ores by laboratory methods; working tests with simple apparatus; adjustment and operation of concentrating machines

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisite or parallel: Mining **81**

Counts, together with Mining **54** and **81**, or with Mining **81**, **73** and **75**, as a minor for the degree of A.M.

91—Mine Administration—2 hours, first half fourth year. Professor Munroe and Professor Kurtz

Administration, organization, and business management, mine accounts, and cost sheets

Required of students in the courses of Mining and Metallurgical Engineering

Pre-requisite: Mining **54**. Parallel: Mining **56**

Counts, together with Mining **54** and **56**, as a minor for the degree of A.M.

94—Mining Law—2 hours, second half fourth year. Professor Kurtz. General principles of real estate law. Historical review of mining laws of various countries. Federal laws, concerning locations on public lands of the United States. State and territorial mining laws

Pre-requisites: Civil Engineering **27**, Mining **54**

95—Mining Conference—1 hour. Dr. Crane. (Optional.) Reading and discussion of papers by the students, on mining practice and based on data accumulated in the course of the summer work in mining

Summer Courses

59—THE SUMMER COURSES IN PRACTICAL MINING are held in June and July, at some mine or mines selected for the purpose, in the vacation between the third and fourth years, and last six to eight weeks, including one week field geology (for details see pages 41-43). Professor PEELE, Professor KURTZ and Dr. CRANE

Pre-requisites or parallels: Mining **51, 52** and **54**, Civil Engineering **15, 27** and **28**, Mechanical Engineering **13** and Geology **105-106**

GRADUATE COURSES

Special courses, consisting of personal instruction, reading, and experimental investigation, will be arranged for advanced students according to their individual needs and ability. These investigations will be made at mines and dressing works either in connection with the Summer class or elsewhere as assigned, with additional work, as required, in the library and in the laboratories of the department. These courses vary in difficulty and in the amount of time necessary, according as the student is a candidate for the degree of A.M. or Ph.D., and according as he pursues mining as a major or a minor subject. The time required is governed by the rule that a course or courses should occupy about 18 hours (outside reading and study included) per week if taken as a major subject, and about 9 hours per week if taken as a minor subject. The following are suggested:

101-102—MINING AND ORE DRESSING—Mining 54, 81 and 82. 4 hours, with laboratory work and reading as required

Pre-requisites: Mineralogy **1-2**, Physics **3-4**, Mining **51** and **52**. Count together as a minor for the degree of A.M.

103-104—MINING ENGINEERING—Mining 54, 56, and 91. 3 hours lectures and reading as required

Pre-requisites: Geology **103-104**, Civil Engineering **28** and Mining **51** and **52**. Count together as a minor for the degree of A.M.

105-106—DESIGN OF MINE PLANT—Mining 71-72, 73 and 75. 3 hours and 5 afternoons drafting-room work

Pre-requisites: Civil Engineering **53-54**, and Mining **51, 52**, and **54**. Count together as a minor for the degree of A.M.

107-108—DESIGN OF ORE-DRESSING WORKS—Mining 80, 81, 82, 73 and 75, with 1 hour conference additional first half-year. 3 hours, and 5 afternoons laboratory and drafting-room work

Pre-requisite: Civil Engineering **53**, Mineralogy **1-2**. Count together as a minor for the degree of A.M.

109-110—MINING—All the undergraduate courses in the department of Mining

See regulations for higher degrees.

201-202—Methods of Mining—Critical study of methods used in some mining region, or for a certain class of deposits; output per man, amount of timber and explosive required, and other details affecting cost. Study of conditions as determining choice of method. Determination of loss of mineral in mining. Accidents to men

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

203-204—Mining Plant—Critical study of rock drilling, or coal cutting, or hoisting, or haulage, or ventilating plant at some mine or mines. Determination of efficiency and conditions affecting same

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

205-206—Deep Mining—Study of problems of deep mining, vertical versus inclined shafts, hoisting and pumping from great depths, temperature and ventilation, efficiency of labor, rock pressure as affecting methods of mining and timbering

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

207-208—Ore Dressing—Critical study of some detail of the ordinary dressing methods, crushing, or screening, or classification, or jigging, or slime treatment, or dry concentration, or magnetic separation, or milling of gold or silver ores, or mechanical preparation of coal. Determination of efficiency, and of conditions essential to success

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

209-210—Examination of a Coal-washing Plant, or of an Ore-dressing Plant—4 to 6 weeks work in the mill and in the laboratory, with conferences

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

211—Examination of a Mineral Property, or a Mine—4 to 6 weeks devoted to field and underground work in the summer school of practical mining, with conferences at convenience of professor

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

213-214—Economic Studies in Mining—Study of existing conditions affecting the production and cost of some mineral or metal, as, for example, anthracite coal, copper, or gold

Pre-requisites: all the courses in Mining
See regulations for higher degrees.

METALLURGICAL ENGINEERING

Officers of the Department of Metallurgy

Henry M. Howe, A.M., B.S., LL.D. .... *Professor of Metallurgy*
Arthur L. Walker, E.M. .... *Professor of Metallurgy*
Bradley Stoughton, Ph.B., B.S. .... *Adjunct Professor of Metallurgy*
William Campbell, Ph.D., D.Sc. .*Adjunct Professor of Metallography*
Edward F. Kern, Ph.D. .... *Instructor in Metallurgy*
Ernest H. Fisher .... *Assistant in Metallurgy*

For tabular statement of program of studies see pages 21 and 24.

General Statement

The primary aim of the four-year course leading to the degree of Metallurgical Engineer is to begin the training of students to take, first, minor administrative positions in metallurgical works, or positions in analytical, metallographic, or testing laboratories of these works; and later to take complete charge of metallurgical and allied industries. The present heads of many great corporations have followed a like path. But beyond this, the course is purposely made very broad, and it trains the students carefully in the methodical planning and the actual execution of difficult work with metals and fire on their own initiative and responsibility, and in interpreting and applying the results of that work. This it does largely in order to help fit the students to plan and direct the work of others in those administrative positions, not only in metallurgy, but also in other activities for which the scientific, that is to say the methodical habit in planning, in executing, and in the interpretation of evidence, and a familiarity with the principles of chemistry, physics, and engineering are valuable. Great stress is laid on this original planning and executing of work, under constant criticism and discussion from the teachers. But the student has first to become very familiar with the actual environment of this high temperature work, so that he may recognize, first, the reality and gravity of these practical difficulties, and second, that it is only by patient thought that they can be overcome. This experience helps to substitute for the boy's overconfidence due to ignorance the man's guarded self-reliance due to his own mastering of difficulties, to shift the point of view from boyhood to that of manhood.

After metallurgy and metallography, which occupy 20 per cent. of the time, the most important subjects are chemistry, mining and engineering, which respectively occupy 22 per cent., 6 per cent., and 30 per cent. of the time, or altogether 78 per cent.

As preliminaries the students are thoroughly drilled in general and physical chemistry, physics, and assaying in order to fit them to study metallurgy and metallography; in mathematics, mechanics, and thermodynamics in order to fit them to study engineering; in certain branches

of civil engineering, in order to begin fitting them to design and build metallurgical works; and in mechanical and electrical engineering in order to begin fitting them to plan and use machinery and electricity in metallurgical manufacture and the allied industries. In studying these general subjects their applications to metallurgical and like manufacture are kept in view, so as to train the student for the life's work actually before him.

Because of long and broad practical experience of the staff in metallurgical manufacture, including most of its important branches, the instruction is based on the most advanced metallurgical practice and science of to-day. In order that the student may get the point of view of the metallurgical investigations of to-day, both practical and scientific, a strong effort is made to interest him in the investigations always going on in the department, as far as the conditions permit. To receptive and mature students this may be of great value.

The course is severe and is designed only for those fitted physically, mentally, and by previous training for strenuous work.

To graduate and other *advanced students* and properly qualified *practitioners* the department's laboratories are open under generous restrictions. *Special* students are admitted for study and work for which they are fitted.

Location and Equipment

Location. New York and the adjacent states produce about half the pig iron and coal, and over 40 per cent. of the total value of the mineral product of the whole country.

Metallurgical Establishments Accessible. Some of the most instructive and advanced iron, steel, copper, lead, zinc, and electrolytic works, where many phases of the best metallurgical practice may be studied, are accessible to these students. Some of these works are among the best in the world. A little farther off are the natural gas, oil, pyrites, granite, and marble quarries of the east. The summer classes visit in different years metallurgical establishments in all parts of the country, including the exreme west and south.

Building. The department occupies about half of the new School of Mines Building generously given by Adolph Lewisohn, Esq., and described on p. 37.

Collections. There are large and growing collections of lecture diagrams; of models and working drawings of metallurgical furnaces and machinery; of apparatus for lecture demonstration of metallurgical principles and processes; and a very large collection of metallurgical specimens and suites, with full descriptive and explanatory notes.

Metallurgical Laboratories. Of these there are three. They serve four chief purposes: (1) to give skill in the use of the instruments of precision of the art; (2) to teach the underlying principles of metal-

lurgy and give familiarity with the conditions, especially as to high temperature, under which metallurgical operations must be carried on, and the use of the principal types of furnaces and other metallurgical apparatus, or in short "Analytical metallurgy"; (3) to give some acquaintance with certain industrial metallurgical processes, or what may be called "Applied metallurgy"; and (4) to give advanced students and qualified practitioners the means of making metallurgical and metallographical researches.

The Instruments of Precision. The students acquire skill with the Le Chatelier thermo-electric pyrometer, of which there are very many of many different kinds, some delicate, some industrial, and some autographic, besides the optical ones of Le Chatelier, of Wanner, and of Mesuré and Noel (Ducretet); the radiation one of Fery; and the calorimetric one of Siemens. There are ammeters and voltmeters for controlling the electric furnaces; sclerometers for measuring hardness; Fremont and Brinell impact testing machines; a tensile testing machine; a Berthelot calorimeter for testing fuels; and many other instruments.

The metal working shop has power-driven machines for cutting specimens, etc.

Most of the furnaces are gas-fired, and those furnaces which are intended for precise work are heated by electric resistance.

Non-Ferrous and Electro-Metallurgical Laboratory. A. For wet and dry metallurgy, the extraction, refining, and alloying of the non-ferrous metals, there are ore roasting furnaces; four gas-fired crucible furnaces; assay muffle furnaces; a high temperature forge; cyanide plants; a filter press; amalgamating pans; a chlorinating barrel; two desilverization kettles; and many pyrometers.

B. For electro-metallurgy, the electrical recovery, deposition, refining, and alloying of metals, there are storage batteries; electrolytic refining vats; and electric furnaces of the Moissan arc, Borcher, and wire resistance types.

The Iron and Steel Laboratory. Here there are electric and double muffle gas furnaces especially designed for this laboratory, in which many full-sized tensile test bars may simultaneously be heated to any temperature up to 1300° C., with uniformity and precision; gas and direct-fired crucible furnaces; gas forges; many special furnaces; and small power-driven rolls for studying the influence of the conditions of rolling on the properties of metals.

The Metallographic Laboratory, for the microscopic and pyrometric study of metals, mattes, slags, etc., in which every student in metallurgical engineering has to become skillful, has microscopes of the Leitz, Le Chatelier, Swift, Beck, and other types; equipment for illumination and photography; many electric resistance furnaces of different types; portable gas furnaces; and many pyrometers.

An Analytical Laboratory in which the students apply to their own metallurgical researches the methods of chemical analysis already learned in the Department of Chemistry (p. 101).

Supplies. There is a large stock of ores, irons, steels, alloys, refractory materials, fluxes, etc., which may be used for investigations.

The Metallurgical Library, containing about fifteen hundred volumes of metallurgical treatises, text books, periodicals, etc., is open to all students, and to others properly introduced. Books may be borrowed under suitable restriction.

The undergraduate instruction consists of (1) class-room work, lectures, conferences, study of text-books, etc. (see p. 55); (2) general laboratory work in metallurgy (see below); (3) training in planning and executing original research; (4) summer courses and other visits to industrial metallurgical works (see p. 54).

The *graduate instruction* consists primarily of original research either in the departmental laboratories, in industrial works, or by study (see p. 58).

Metallurgical Laboratory Instruction

In order to become familiar with a wide range of the conditions and principles of metallurgy, the student makes many experiments, each illustrating, testing, or aiming to discover some one or more metallurgical principles or reactions, or the conditions which permit a given reaction to occur. He must, in general, after each experiment enunciate briefly in writing the law to which his results point, or indicate how far those results severally and collectively support or oppose a given proposition.

These experiments relate chiefly to such subjects as the influence of thermal treatment on the properties and microstructure of metals and alloys, especially iron and steel; the determination of melting points and other temperatures; the relation between the composition of slags and their fusibility; the influence of fluxes; the behavior of refractory materials at high temperatures, either alone or in contact with different slags; the temperature limits and the reactions of roasting operations; the influence of various bodies on the reactions which take place in roasting, in the cyanide process, in the chlorination process, and in pan amalgamation; the interaction of carbon and molten oxides, sulphides, silicates, etc., etc.

The Art of Investigation (Course 176). There is a demand, which cannot now be filled even by importation, coming from the makers of steel and of certain alloys, for young metallurgists to make original investigations especially in metallography. Fitness for such places requires knowledge not only of metallurgy but also of the art of investigation itself.

To acquire this, the student has to reduce to precise terms a series of problems which are given him purposely in vague form;

and to plan and specify systematically the experimental procedure for solving them. He then executes an investigation thus planned, and, in his graduating thesis, describes his experiments and results in detail, summarizes them in tables and diagrams, and shows briefly and clearly what their answer to his problem is, specifying which of them support and which oppose each definite proposition.

In the Two Summer Courses, lasting six weeks, No. 64 for iron and steel and No. 62 for the other metals, the students are taught singly and in classes at metallurgical works, sometimes in the East, sometimes in the West. A prominent part of these courses consists of work such as (1) making written descriptions of the processes, and sketches of the furnaces and other apparatus, with dimensions, usually from the student's own estimate; (2) explaining the principles on which the processes rest, the reasons for the special shapes and sizes of the apparatus, the chief technical difficulties, how they are overcome, and by what tests the processes are controlled; and (3) giving the number and kinds of men, and as far as practicable the consumption of fuel and other materials, the thoroughness of recovery of the metal sought, etc. From an imaginary set of prices and wages the students have to calculate the cost and profit of certain operations. Students in Mining Engineering must attend one week of Course 62, and those in Mechanical Engineering may attend one week of Course 64.

Summer Session. A lecture and laboratory course in metallography (Course s58) is given in connection with the summer session in New York.

Metallurgical Excursions, open to students in Metallurgical Engineering only, are made both during the term and in the Easter recess, to the metallurgical works near the University. The students may visit independently or join the frequent excursions to the neighboring foundries, machine shops, electrical works, mines, and points of geological interest.

Information as to instruction and the equipment available for students of Mining and Metallurgy in other departments of the University is to be found in this pamphlet as follows:

Other Departments

COURSES IN METALLURGICAL ENGINEERING

Undergraduate Courses

2—Metallurgy of Copper—The properties of copper and its alloys; the principles of roasting; the reverberatory and cupola smelting processes for oxide and for sulphide ores; the converter or Bessemerizing process. Text-book: Peters' *Modern Copper Smelting*. 2 hours lecture, third year. Dr. Kern

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of students in the Schools of Mines and Chemistry

3—Metallurgy of Lead, Silver, Gold, Zinc and the Minor Metals—Properties, alloys, ores, methods of extraction, separation and refining. Text-book: Hofman's *Metallurgy of Lead, etc.*, Collins' *Metallurgy of Silver,* Rose's *Metallurgy of Gold,* Ingalls' *Metallurgy of Zinc, etc.,* Reference, Schnabel's (Louis) *Handbook of Metallurgy.* 3 hours lecture, fourth year. Professor Walker

Pre-requisite: Metallurgy 2 and 62, for students in the School of Mines

Required of students in the Schools of Mines and Chemistry

4—Metallurgy of Iron and Steel—The blast furnace, puddling, Bessemer, open hearth and crucible processes. Rolling and forging metals. The properties of iron and steel as influenced by composition (including alloy steels), by mechanical and thermal treatment. The microscopic constitution of iron and steel. Text-book: Howe's *Iron, Steel and Other Alloys.* 2 hours, second year. Professors Howe and Campbell

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of second year students in Civil, Electrical, Mechanical, Chemical Engineering and Chemistry

5a—Metallurgy of Iron and Steel—The properties of steel, cast iron and wrought iron, as influenced by composition and by thermal and mechanical treatment, together with a brief account of the chief processes by which they are made. Text-book: Stoughton's *Metallurgy of Iron and Steel.* 2 hours lecture during October and November, fourth year. Professor Campbell

Pre-requisite: Chemistry 3-4 and Physics 3-4

Required of students in the School of Mines

5b—Electrometallurgy—The theory and the application of the electric current to; extraction of metals from ores by electrolysis and by smelting; the refining of metals and the recovery of associated constituents; and the production of refractory alloys and steels in the electric furnace. The metals considered are copper, lead, iron, nickel, antimony, silver, gold, aluminium and zinc, and the alloys of iron with

silicon, chromium, tungsten, vanadium, etc. 2 hours lecture December and January, fourth year. Dr. KERN.

Pre-requisite: Chemistry 3-4 and Physics 3-4
Required of students in the Schools of Mines and Chemistry

52—METALLURGY OF COPPER—Advanced Course. 1 hour lecture or conference, third year. Dr. KERN

Pre-requisite or parallel: Metallurgy 2
Required of students in Metallurgical Engineering

53—METALLURGY OF LEAD, SILVER, GOLD, ZINC, ETC.—Advanced Course. 1 hour lecture or conference, fourth year. Professor WALKER

Pre-requisite or parallel: Metallurgy 3
Required of students in Metallurgical Engineering

55a—METALLURGY OF IRON AND STEEL—Advanced Course. 3 hours lecture or conference, second year. Professor HOWE

Pre-requisite or parallel: Metallurgy 5a
Required of students in Metallurgical Engineering

55b—ELECTROMETALLURGY—Advanced Course: The construction of electrolytic refineries and electric furnaces; calculations of current and power efficiencies; treatment of by-products; the electrolytic precipitation of cyanide solutions from leaching of gold and silver ores; the production of solid deposits; the purification of electrolytes; etc. 1 hour conference during December and January, fourth year. Professor WALKER and Dr. KERN

Pre-requisite or parallel: Metallurgy 5b
Required of students in Metallurgical Engineering

57—CONSTITUTION AND PROPERTIES OF ALLOYS—Text-book: Howe's *Iron, Steel and Other Alloys.* 3 hours lecture or conference and one afternoon laboratory, during December and January, fourth year. Professor CAMPBELL

Pre-requisite: Metallurgy 2. Pre-requisite or parallel: Metallurgy 5a or 4
Required of students in Metallurgical Engineering

58—METALLOGRAPHY OF IRON, STEEL AND INDUSTRIAL ALLOYS—Constitution of iron, steel, brasses, bearing-metals, etc.; comparison of good with faulty material; cause and effect of defects; heat treatment, etc. Total of three lectures and three or more afternoons laboratory. Professor CAMPBELL

Pre-requisite or parallel: Metallurgy 5a or 4

62—SUMMER COURSE IN NON-FERROUS METALLURGY—For description see page 54. Summer after third year. Dr. KERN

Pre-requisite: Metallurgy 2
Required of students in the School of Mines

64—SUMMER COURSE IN FERROUS METALLURGY—For description see page 54. Summer after second year. Professor CAMPBELL

Pre-requisite: 5a or 4
Required of students in Metallurgical Engineering

72—METALLURGICAL LABORATORY—Pyrometry; microscopic metallography; thermal treatment of steel; roasting; desilverizing base bullion; cyaniding of gold ores. Text-book: Howe's *Metallurgical Laboratory Notes.* Total of 10 afternoons, fourth year. Professor CAMPBELL and Dr. KERN

Pre-requisites: 2, 5a (or 4), 5b and 3 (or parallel).
Required of students in Mining Engineering

77-78—THESIS

Pre-requisite 1, 5a (or 4), 5b, 3 (*or parallel*), 171 and 175
Required of students in Metallurgical Engineering

171—METALLURGICAL LABORATORY—Pyrometry; calorific power of fuels; microscopic study of metals and alloys; thermal and mechanical treatment of steel and cast iron; roasting and smelting of ores; refining black copper; desilverizing base bullion; cupelling, roasting, lixiviating, cyanide, chlorination and electro-metallurgical processes; fusibility and other properties of slags and of refractory materials (see page 10, *Metallurgical Laboratory Notes*). Text-book: Howe's *Metallurgical Laboratory Notes.* 2 afternoons, third year. Professor CAMPBELL and Dr. KERN

Pre-requisite, 1, 5a (or 4), 5b, 3 (or parallel)
Required of students in Metallurgical Engineering

175—THE ART OF METALLURGICAL INVESTIGATION—A total of ten afternoons' conferences. Professor CAMPBELL

Pre-requisite: 1, 5a (or 4), 5b and 3 (or parallel)
Required of students in metallurgical engineering and graduate students carrying on investigations.

S. 58—Five hours lectures or recitations and 5 hours laboratory per week. Professor CAMPBELL

Metallography of iron, steel and industrial alloys. Constitution of iron, steel, brasses, bearing metals, etc. Comparison of good with faulty material: Cause and effect of defects. Method of work. Elements of microscopic and pyrometric examination. Heat treatment of iron and steel, bronzes, etc. Application of metallography to other opaque material; mattes, speisses, ore bodies, etc.

Pre-requisites: Elementary Chemistry and Physics; Elementary Metallurgy.

Graduate Courses

Special courses, consisting of original research, will be arranged for advanced students according to their individual needs and abilities. Most of these researches will consist of work in the departmental laboratories, but others will consist of study, and still others of work in industrial establishments.

The amount of time required for these courses is governed by the rule that a course or courses should occupy 12 hours a week (preparation included) if taken as a major subject, and 6 hours a week if taken as a minor subject for a degree of A.M., or half minor for a degree of Ph.D. The following list shows what kinds of subjects are suited to these courses:

201-202 (*a*)—Advanced work on some problem in general metallurgy, as for example:

In Calorimetry: Determination of the calorific power of fuels, or testing some law in calorimetry;

In Pyrometry: Determination of the temperatures of metallurgical and other industrial high-temperature operations;

On Refractory Materials; their resistance to heat and corrosion; their tendency to slack; their contraction and expansion, etc.;

In Electro-metallurgy: Testing electro-metallurgical principles and refining, extraction and depositing process;

On Slags: The formation points, melting points, flowing points, and their density and viscosity when molten;

(*b*)—In the Metallurgy of Copper:

The chemistry of roasting processes, especially the elimination of arsenic and sulphur; chloridizing and sulphate roasting;

The reactions of smelting processes;

Wet methods of extraction;

(*c*)—In the Metallurgy of Lead, Silver, Gold, etc.:

The pot-roasting of sulphides, and others mentioned above under (*b*);

(*d*)—In the Metallurgy of Iron and Steel:

The chemistry of the blast furnace;

The chemistry of the basic dephosphorizing processes;

The heat treatment of iron and steel: its physical, crystallographic and chemical effect;

The components and constitution of iron, steel, and alloy steels;

(*e*)—On Alloys: The constitution and properties of alloys, embracing a microscopic, pyrometric and mechanical or physical examination with a correlation of the results;

(*f*)—In Metallography: Metallography of iron, steel, industrial alloys or metallurgical products as mattes, slags, etc.

Pre-requisite for 201-202, Metallurgy 2, 5a, 5b, 3 and 71-72, or equivalent.

CIVIL ENGINEERING

List of Officers

William Hubert Burr, C.E.	*Professor*
Earl Brink Lovell, C.E.	*Professor*
Ira H. Woolson, E.M.	*Adjunct Professor*
Adolph Black, C.E.	*Adjunct Professor*
Charles E. Morrison, C.E., A.M.	*Tutor*
Myron Samuel Falk, C.E., Ph.D.	*Lecturer*
Elihu C. Church, C.E.	*Lecturer*
J. S. Macgregor, M.Sc.	*Assistant*
Francis S. Foote, Jr., E.M.	*Assistant*
——————	*Assistant*

For tabular statement of program of studies see pages 21 and 26.

General Statement

The four-year course leading to the degree of Civil Engineer is designed to afford a thorough analytical training, as well as numerous and extended practical exercises in those matters which pertain to the profession of the civil engineer, both in regard to all classes of structures and public works and in connection with the various developments and applications of power by the use of steam, electric, water, and air motors. This course is also designed to be an educational preparation for those duties or functions of an executive character whose discharge in connection with the management of public or other works requires, or is rendered more efficient through, a thorough knowledge of civil engineering. The breadth and nature of this educational training adapts it no less efficiently to the purposes of those who intend to follow callings not of an engineering character but which may be related more or less to manufacturing, to structural matters, or to the development and application of power. The theoretical portion of the instruction is based largely upon the courses given in the departments of Mathematics, Mechanics, and Physics, and the results obtained are applied to practical engineering work. Special stress is laid upon the design by the student of the various structures and machines which the civil engineer is called upon to construct in the practice of his profession. The instruction is given by lectures, demonstrations by the student, and frequent conferences, co-ordinate with which the work of design is continuously carried on. It covers comprehensively the subjects of surveying, road and railroad engineering, water supplies of cities and

towns, irrigation, sanitary engineering, including sewage disposal; both graphic and analytic treatment of all metallic structures, foundations, retaining and reservoir walls, high masonry dams, sewer systems, hydraulic engineering, rivers and harbors, pumping engines, hydraulic, steam, and electric motors.

Ample facilities are afforded for post-graduate students in civil engineering, and special students are admitted to various engineering courses of the department upon evidence of proper qualifications.

Equipment

The school possesses an unusually full equipment of engineers' and solar transits, levels, plane tables, compasses, and all accessories, as well as smaller instruments. Current meters, hook gauges, and floats of various types are also used in making observations on the flow in, and discharge of, rivers and canals. A complete set of sections of iron and steel shapes, models and photographs of engineering works, together with working plans of the latter, are in the department for the use of students. The hydraulic laboratory affords opportunity for the practical operations of measuring the discharge through weirs and other orifices, the flow through open channels and closed pipes, frictional and other resistances in pipes and open channels, as well as for meter gaugings, and for general hydraulic investigations. The testing work in the mechanical laboratory includes the complete tests of various structural materials in tension, compression, bending, and torsion, including the observation and digesting of all corresponding data.

A cement-testing laboratory is fully equipped with testing machines, briquette molds, tanks, and other apparatus requisite for all classes of investigations in the nature and physical properties of cements and cement mortars.

A complete laboratory for the testing of road materials has been established and is constantly in use for investigations connected with materials suitable for road building. The facilities offered by the laboratory are full and sufficient to make all tests required to determine resistance to abrasion, classification of sand, gravel and broken stone and the cementing power of all qualities of road materials. The laboratory is at the service of students and is used by them, both for the ordinary prosecution of studies to which the determination of results is related and for the purposes of thesis work, and other similar investigations.

The Materials Testing Laboratory is located at the north end of the main floor of the Engineering Building. It is fully equipped with modern appliances for the conduct of tests upon all structural materials. There are seven testing machines varying in capacity from 600 lbs. to 400,000 lbs., representing all American types, including a 150,000-lb. Emery hydraulic power machine, which is a standard of accuracy, and

the refinement of mechanical construction. These machines are suited to make tension, compression, transverse and torsion tests upon metals, also to make all desired tests upon building materials such as timber, stone, brick, concrete blocks or concrete-steel beams, columns, partition blocks, and all built up materials.

The laboratory is also liberally supplied with a large assortment of extensometers, deflectometers, micrometers, gauges, and similar instruments of precision for measurement of test pieces.

Other apparatus such as delicate scales of different sizes for use in absorption and freezing tests on building materials, also pyrometers and furnaces for the conduct of fire tests upon all kinds of fire-resisting materials are available. Near the University is established the commodious Columbia Fire Testing Station. This is under control of the officers of the testing laboratory, and is equipped with several large test buildings and all necessary apparatus and appliances for making regulation fire, load and water tests upon walls, floors, partitions, etc., in full size units, as prescribed by the building codes of New York and Philadelphia. Commercial work of this character, as well as in the laboratory, is continually in progress, and is open to student observation at all times, thus keeping them in touch with the practical demands of the hour in this line of investigation work.

GENERAL STATEMENT OF THE SUMMER COURSES IN SURVEYING AND GEODESY AT CAMP COLUMBIA, MORRIS, CONN.

The instruction in Surveying given by the Department of Civil Engineering consists of lectures, recitations and problem work, supplemented by instrumental practice in field work, and office work in computation and mapping. The general lectures and recitations are given at the University. The field practice is given during the three summer vacations of the regular four-year course. The subject of Geodesy is given by the Department of Astronomy, and the practical work connected therewith is done under the supervision of that department by students in Civil Engineering during a portion of five weeks of the summer vacation between the third and fourth years. The theory of Plane Surveying, including Railroad Surveying, is given by the Department of Civil Engineering. The field practice is conducted under the direction of the Department at Camp Columbia, a point in the country near Litchfield, Conn., where ample facilities are provided for all requisite operations, and where the topography and climate are admirably adapted to the practical work of surveying. Five weeks' continuous attendance is required of all students in the Schools of Mines, Engineering and Chemistry during the summer between the first and second years. (See

Course 15 C. E., page 65.) Five weeks' additional attendance is required of all students in Civil Engineering (see Course 25 C. E., page 65) and five weeks of all students in Metallurgy (see Course 27 C. E., page 65), and eight weeks of all students in Mining (see Courses 27 and 28 C. E.), during the summer between the second and third years. Nine weeks' continuous attendance is required of all students in Civil Engineering during the summer between the third and fourth years (see Course 26 C. E., Course 107 Astronomy and Course 71 C. E., pages 65, 112, 168). During the summer of 1908 the Summer Courses in Surveying and Geodesy will be in session about fifteen weeks.

No student taking these courses will be excused from any part of any course on account of work done elsewhere, unless that work has been done under the immediate direction of an instructor of an institution which grants degrees in Mining or Civil Engineering. In no case will credit be given except upon the evidence of field-notes, maps, and reports presented to the Professor in charge of the courses.

Two examinations will be held at Camp Columbia for new students, special students and students who fail to receive a mark of 5.0 or more in Course C. E. 2. The first examination will be held July 3, and the second one August 7, 1908.

The University provides houses or tents having elevated floors, furnished with cots and drafting tables. There are also provided a dining hall and bath house. Arrangements may be made for laundry work to be done in the neighborhood. A supply of drafting materials (not instruments) is kept on sale. Especial attention is given to the wholesome and substantial character of the table.

The cost of board is fixed at $6.75 per week and this amount is charged against the individual deposits. The account against each student is reckoned from the day announced for his division to assemble. No allowances or reductions are made for absences of less than one week, and then only in the event of notice having been given and excuse granted by the officer in charge at least one day in advance of the beginning of such absence.

Each student intending to take work in these courses must send his address to the officer in charge not later than May 10. Subsequent changes in plans must be reported at once.

Every student must be present on the day appointed for his division to assemble, unless other arrangements have been made with the officer in charge. Failure to comply with this regulation may be sufficient cause to refuse the applicant's admission to the courses.

Deposits made at Camp Columbia are to meet Camp expenses, viz.: board, laundry, charges for drawing material, note books, etc., also to cover any damage to, breakage, or loss of instruments or Camp equipage, and transportation of students and their baggage from the station to the camp.

Every student upon his arrival at Camp shall deposit the amount specified below with the officer in charge of the school, or with his authorized assistant. The amount of the deposit will vary with the number of surveying courses for which the individual student registers.

The deposit for Course 15 shall be $50.
The deposit for Course 25 shall be $50.
The deposit for Course 26 shall be $20.
The deposit for Course 27 shall be $50.
The deposit for Course 28 shall be $35.
The deposit for Course 71 shall be $35.
The deposit for Geodesy 107 shall be $30.

The deposit for any one *survey* of Course 15, 25, or 27 shall be $15.

Every student who registers for two or more courses shall deposit an amount equal to the sum total of the deposits above specified for the respective courses.

All balances of these deposits which shall remain to the credit of the student upon his withdrawal from the Session shall be returned to him at its close, at which time he shall personally examine and audit his account.

Fees

For statement concerning tuition fees and laboratory fees see page 17 of General Announcement.

Schedule of Attendance

In 1908 the School Session opens May 30 and closes September 12.

Div. A—May 30 to July 4, 5 weeks—Course 25
Open for all 2d, 3d, 4th year students in Civil Engineering who have completed Course 15.

Div. B—May 30 to July 4, 5 weeks—Course 27
Open for all 2d, 3d, 4th year students in Mining Engineering and Met. Engineering who have completed Course 15.

Div. C—May 30 to July 4, 5 weeks—Course 15
Open for all 2d, 3d, 4th year students in Mining, Metallurgy, Chemical Engineering and Civil Engineering who have not finished Course 15.

Div. D—May 30 to July 4, 5 weeks—Course 15
Open for 25 or 30 men of all 1st year students as assigned on basis of scholarship.

Div. E—July 4 to August 8, 5 weeks—Course 25
Open for 2d, 3d, 4th year students in Civil Engineering who reported with Div. C or Div. D for Course 15.

Div. F—July 4 to August 8, 5 weeks—Course 27
Open for 2d, 3d, 4th year students in Mining and Metallurgy who reported with Div. C or Div. D for Course 15.

Div. G—July 4 to August 8, 5 weeks—Course 15

Open for 1st year students as assigned from those not assigned to Div. D and of those who do not register for the summer session in New York. (Probably 75 men.)

Div. H—July 11 to August 15, 5 weeks—Course 26 C. E. and Course 107 Astronomy

For 3d and 4th year students in Civil Engineering who have finished Course 15 and Course 25.

Div. I—August 8 to September 12, 5 weeks—Course 15

For 1st year students as assigned from those not assigned to Div. D or Div. G. (Special dates may be arranged for those who attend Summer Session at Columbia University in New York.)

Div. J—August 15 to September 12, 4 weeks—Course 71

For 3d and 4th year students in Civil Engineering who have finished Course 15, Course 25 and Course 51-52.

Div. K—August 15 to September 12, 4 weeks—Part of Course 25 or Course 27

For 2d, 3d, 4th year students in Mining, Metallurgy and Civil Engineering reported with Div. C and who withdrew with permission on July 6 to attend Summer Session at Columbia University, in New York

Div. L—*August 15 to September 12, 4 weeks—Part of Course 15

For special students not heretofore registered at Columbia University but who have been in attendance at Summer Session at Columbia.

*Special students wishing to enter this course and who are not in attendance at Summer Session in New York should report August 8.

Div. M—August 22 to September 12, 3 weeks—Course 28

For 2d, 3d, 4th year students in Mining who have finished Course 15, Course 27 and Course 23.

COURSES IN CIVIL ENGINEERING

C. E. 2—Theory of Surveying—For first year students in the Schools of Mines, Engineering, and Chemistry. Text-book: Tracy's *Plane Surveying.*

Methods of measuring angles and distances. Cumulative and compensating errors, and corrections to be applied. Limits of precision. Use, care, and adjustment of the engineer's transit, level, and compass. Magnetic declination and variation. Local attraction. Relocation of old lines by compass bearings. Erroneous standards. Surplus and deficiency. Significance of monuments. Traverses; computations of area and error of closure. Laying out and dividing up land. System of public land surveys. Topographic surveys; transit stadia and plane table methods. Triangulation. City surveying, subdivision and resurveys. Interpretation of deed descriptions.

21—ROAD ENGINEERING—Road resistances—Design, construction, maintenance and repair, of Dirt, Gravel, Broken Stone and Miscellaneous Roads—Street Location—City pavements;—Belgian and Granite Block, Brick, Asphalt and Wooden Block—Foundations—Grades—Drainage—Specifications. Reference and text-books: Morrison's *Highway Engineering*. Lectures and recitations, 2 hours. Mr. MORRISON.

C. E. 15—SURVEYING BETWEEN THE FIRST AND SECOND YEARS—Field work and office work. Five weeks. Five surveys. *Survey 1* includes pacing and chaining, ranging out lines, contouring with hand level, mapping. *Survey 2* consists of the adjustment of the level and in running a line of differential levels, Note book and report. *Survey 3* consists of the adjustment of the transit, angle reading by repetition, determination of stadia constant, and running an azimuth traverse in which horizontal distances are determined by the stadia, and differences of elevation computed from the vertical angle. Note book and map. *Survey 4* consists of a compass survey of a closed field, location of boundaries and principal details, computation of area, and map. *Survey 5* consists of repetition traverse of a closed field, distances being measured by steel tape corrected for catenary, pull, and temperature. Determination of magnetic declination by observation on Polaris. Professor LOVELL and Mr. FOOTE, and assistants. Pre-requisite, 2.

23—THEORY OF RAILROAD SURVEYING—An abridged course, for students in Mining Engineering, covering the same subjects as are taken in Course 51-52. 2 hours and 1 afternoon problem work. Professor LOVELL and assistant. Prereq. 15.

C. E. 25—SURVEYING BETWEEN THE SECOND AND THIRD YEARS. Field work and office work. 5 weeks. 5 surveys. *Survey 1* consists of running a line of levels for a water main or sewer, plotting profile, and computation of excavation. *Survey 2* consists of a topographic survey with plane table. Intersection, re-section, and traverse methods to be used, and map made. *Survey 3* consists of a topographic survey with transit and stadia; note-book and map. An optional course in photographic surveying may be offered in 1909. *Survey 4* consists of solar observations with transit and solar compass for the determination of the true meridian and magnetic declination. *Survey 5a,* City surveying, consists of the division of land into city blocks and subdivision into lots and the location of the street and lot lines; grade lines for streets and grades at street intersections; location and grade of sewers; including map, profile, and computation of excavation for street opening and sewer line. Relocation of lot lines and problems in surplus and deficiency, map showing property with record line and encroachments. Location of lines for buildings, bridge abutments, etc. Professor LOVELL, Mr. FOOTE and assistants. Pre-requisite, 15.

C. E. 26—SURVEYING BETWEEN THE THIRD AND FOURTH YEARS.

Hydrographic Survey. Field and office work. Two weeks. Survey made in conjunction with Geodetic Survey (total time 5 weeks, see page 112, Dept. of Astronomy), which furnishes main triangulation net for topographic and hydrographic control. Hydrographic survey consists of secondary triangulation, topography on shore by stadia, soundings, observations on outlet by current meter for river discharge, adjustment of angles, computation of triangulation system, also of river discharge, map and report. Professor LOVELL, Mr. FOOTE and assistants. Pre-requisite, 25.

C. E. 27—SURVEYING BETWEEN THE SECOND AND THIRD YEARS—Field work and office work. 5 weeks. 5 surveys. Same as C. E. 25 except Survey 5a is omitted and Survey 5b is added. *Survey 5b* consists of the location of a mining claim 1,500 feet long by 300 feet wide in conflict with existing claims, and the determination of the areas in conflict. The claim is located upon an outcrop of assumed dip and strike, in such a manner as to keep the center line close to the outcrop. Reports and maps. Professor LOVELL, Mr. FOOTE and assistants. Prerequisite, 15.

59—SANITARY ENGINEERING—Treatment and disposal of sewage and refuse of manufacturing—Sedimentation by gravity and by chemical precipitation—Treatment of effluent by continuous and intermittent sand filtration—Septic tanks—Contact beds—Percolating or trickling filters—Fertilization—Intermittent application to soil with under-drainage—Disposal of sludge—Plants for sewage treatment—Theory and construction of sand filters—Pollution of potable water and its purification by continuous and intermittent sand filtration—Mechanical filtration—Copper sulphate, ozone and other treatments for special waters—Design of sand filter for water purification. 2 hours lectures, and 2 afternoons in January in Bacteriological Laboratory. Examinations of and reports on typical purification works. Biology and Bacteriology of drinking water. Text-books: *Filtration of Public Water Supplies,* Hazen; *Purification of Sewage,* Barwise. Prof. BLACK. Prereq. Chemistry, 81-82.

75—HYDRAULICS—Flow of water through orifices—Time required for discharge of canal locks and similar volumes—Weir discharge and gauging by weirs—Gauging of water for systems of irrigation—Flow through and discharge of pipes—Design of pipe systems for city waterworks—The Venturi meter—Flow in and discharge of open canals and rivers—Gauging of streams by current meters, floats and other means—Backwater—Flow of compressible fluids. 4 hours lectures, with conferences and problems. Text-book: Merriman's *Hydraulics.* Prof. BLACK. Prereq. Mechanics 102, Math. 5.

76—HYDRAULICS—for students in Mining Engineering—Course 75 abridged. 2 hours lecture and recitation. Prof. BLACK and Mr. MORRISON. Prereq. Mechanics 102, Math. 5.

77—HYDRAULICS—for students in Electrical Engineering—Similar to course 75, but shorter. In addition it deals with the general considerations of rainfall, evaporation, percolation, run-off, net yield and storage; conduction of water from source to power-house, hydraulic losses and effective head on wheel; estimation of power. 2 hours lectures. Text-book: Merriman's *Hydraulics*. Reference book: Turneaure and Russell's *Public Water Supplies*. Prof. BLACK.

78—HYDRAULICS—for students in Mechanical Engineering—Same as 76. 2 hours a week. Prof. BLACK.

28—SURVEYING BETWEEN THE SECOND AND THIRD YEARS—Field work and office work—3 weeks—Railroad surveying—Reconnaissance—Preliminary survey—Location—Cross-sectioning—Computation—Economic comparisons from construction and operating standpoints—A complete survey for the location of a line two to five miles long is made, with all the attendant computations requisite for placing the work under contract. Maps, plans, profiles, calculations of earthworks, estimates and specifications. Daily conferences with instructor in charge of party. Professor LOVELL, Mr. FOOTE and Assistants. Prereq. 23, 27.

51-52—THEORY OF RAILROAD SURVEYING—Simple, compound, and reversed curves—Transition curves—Switch work—Cross-section work—Earthwork computations—Cost of earthwork; cut and fill—Borrow—Waste and overhaul—Office work; Profile with mass curve showing proper distribution of excavation. Lectures and practical problems. 2 hours and 1 afternoon, first term, and 3 hours and 1 afternoon problem work. Reference books: Searle's *Field Engineering* and Crandall's *Transition Curve and Earth-work*.—Professor LOVELL, Mr. FOOTE and Assistant. Prereq. 15.

53-54—ELASTICITY AND RESISTANCE OF THE MATERIALS OF ENGINEERING—Laws of elasticity in homogeneous materials—Coefficients of elasticity—Relations between stresses and strains—Common and exact theories of torsion and flexure—Elastic limits, working stresses, and ultimate resistances of wrought iron, cast iron, steel, alloys, timbers, building-stones, cement, concrete, and masonry—Reinforced concrete construction—Complete treatment of simple and continuous beams—The design and construction of iron, steel, and timber columns and beams, including the design and construction of plate girders—Shafts—Cables—Fatigue of materials—Specifications—Testing Laboratory—Discussion of properties of structural materials as shown by results of testing, by tension, compression, bending, and torsion—Report of tests. 5 hours lectures and recitations first half. 6 hours first half-year of problem, design and laboratory work, 3 hours second half. Reference and text-book: Burr's *Elasticity and Resistance of Materials*. Professor BURR, Professor WOOLSEON, and Mr. MORRISON. Prereq. Mechanics 101-102.

58—Masonry Structures—Pressure and abutting power of earth—Design and construction of retaining walls—Stability of masonry structures in general—Stability of towers and chimneys under wind pressure—Theory and design of arches with vertical and inclined loads—Theory and design of reservoir walls, earth and high masonry dams—Theory and design of masonry domes—Cement, concrete, and masonry. Reference books: Cain's *Retaining Walls* and Baker's *Masonry and Foundations.* Lectures 3 hours with frequent conferences and continuous work in design. Cement and mortar testing in the cement-testing laboratory are required of all students. Mr. Morrison. Prereq. Mechanics 101-102, Mineralogy 5.

61—Analytical Theory of Trusses—The truss element—Simple cantilever and non-continuous trusses with parallel chords—Fixed and moving loads—Through and deck spans—Positions of any system of concentrated moving loads for greatest chord and web stresses when chords are both parallel and non parallel—Combination of moments and graphic methods—Skew and irregular trusses—Applications to bridge and roof trusses—Braced arches and arched ribs. 2 hours lectures, with frequent conferences and problems in computations of stresses and preparation of stress sheets. 1 afternoon of problem and design work in the drawing academy. Reference and text-book: Burr and Falk's *Metallic Bridges.* Mr. Morrison. Prereq. Mechanics 101-102

62—Graphic Statics—for students in Civil Engineering—Equilibrium polygon, and polygonal frames for all systems of loads—Graphical representations of shears and moments for both non-continuous and continuous beams—Fixed and moving loads—Lines of influence—Applications to bridge and roof trusses. 2 hours lectures. 1 afternoon of problem and design work in the drawing academy. Reference and text-book: Burr and Falk's *Influence Lines.* Mr. Morrison. Prereq. Mechanics 101-102.

64—Graphic Statics—An abridged course, covering the subjects taken in Course 62. 1 hour and one afternoon, for mining engineers and metallurgist. Mr. Morrison. Prereq. Mechanics 101-102.

71—Surveying between the Third and Fourth Years—Field work and office work—4 weeks—Railroad Surveying—Reconnaissance—Preliminary survey—Location—Cross-sectioning—Computations—Economic comparisons from construction and operation standpoints—A complete survey for the location of a line two to five miles long is made, with all the attendant computations requisite for placing the work under contract. Maps, plans, profiles, earthwork quantities, estimates and specifications. Daily conferences with instructor in charge of party. Professor Lovell, Mr. Foote and Assistants. Prereq. 51-52 and 25.

85—FOUNDATIONS—Earth foundations—Foundations for buildings—Safe loads on masonry and foundation beds—Pile driving and pile foundations—Safe loads for piles—Protection and preservation of piles and timber—Sheet piling and coffer-dam methods—Pneumatic foundations and caisson work—Open dredging—Bridge piers of masonry and cylinders—Piers for deep foundations—Methods of working in quicksands—Tunneling. Reference books: Patton's *Foundations* and Baker's *Masonry and Foundations*. 2 hours lectures, with frequent conferences and continuous work in design. 1 afternoon of problem and design work in the drawing academy. Professor BURR. Prereq. 57-58, Geology 18.

87-88—THE DESIGN AND CONSTRUCTION OF BRIDGES, ROOFS, AND BUILDINGS—Railway and highway bridges—Pin and riveted connections—Single and multiple system of bracing—The design of details for bridges, roofs, and buildings—Floors for railway and highway bridges—The design and operation of draw-bridges, including engines, locking, lifting, and turning machinery—Cantilever structures—Wind loads and stresses—Single and double-track viaducts or trestles in iron, steel, and timber—Lateral and transverse systems of bracing—The design and construction of elevated railroads—The complete designs of railway structures, with estimates of cost—The erection of iron, steel, and timber structures, including the cost of erection. 2 hours lectures and recitations, with frequent conferences and continuous work in design. 1 afternoon of problem and design work in the drawing academy. First half-year only for sanitary engineers. Reference and text books: Burr and Falk's *Influence Lines;* Burr and Falk's *Metallic Bridges*. Prof. BURR, Mr. MORRISON and Dr. FALK. Prereq. 53-54, 61-62.

89-90—RAILROAD ENGINEERING—Construction and operation—Train resistance, sources and probable value—Curvature and grades, their relation to velocity and maximum train-load—Effect of momentum—Reduction of grades at starting points—Balance of grades for unequal traffic—Study of annual reports—Analysis of operating expenses—Cost of operating, including maintenance, per train mile—Itemized statements of costs and percentage to total cost—Cost of extra distance, curvature, rise and fall, or of additional trains—Effect of roadbed on cost of running trains—Justifiable expenditure in construction to save one mile of distance, one degree of curvature, one foot of rise and fall, or to reduce ruling grade .1% per daily train per year—Pusher grade for one or more assistant engines—Economical use of pusher grades—Cost of excessive or limiting curvature—Value of additional traffic—Principles to follow in locating new lines—General policy of improvements in old lines—Principles in design and construction of railroad yards and terminals—Computations and detail drawings of turnouts, slip switches and ladder tracks—Development and present practice in

block signalling and interlocking, with problems in design and estimates of cost of installation—Classification and cost of earthwork—Graduation, cross section in excavation and embankment, and protection of slopes—Ordinary and extraordinary methods of drainage—Water supply, its quality, storage, and delivery—Principles of construction of wooden trestles and masonry culverts, including preparation of standard plans and estimates of cost—Ballast—Track, track accessories and maintenance of way details—Organization—Management. 3 lectures. 5 hours of problem and design work in the drawing academy. Reference books: Wellington's *Railway Location—The Block System,* Adams—Camp's *Notes on Track*—Dewsnap's *Railway Organization and Working.* Professor LOVELL. Prereq. 71.

94—THE DESIGN AND CONSTRUCTION OF SEWERS, AND IRRIGATION—Sewerage and surface drainage of cities and towns—Separate and combined systems of sewers—Capacities of mains and branches—Catch basins—Manholes—Chimneys or ventilators—Flush tanks—Outfalls—Grades—Flow or discharge of sewers—Construction. Irrigation of land—Amounts and periods of application—Construction of, and flow through, diversion and distributing canals. Text and reference books: *Separate System of Sewerage,* Staley and Pierson—*Sewer Design,* Ogden—*Irrigation Engineering,* Wilson. 2 hours lectures, recitations, problem and design work. Prof. BLACK. Prereq. 26, 59, 75.

95—ENGINEERING CONTRACTS AND SPECIFICATIONS—An elementary course dealing with the more common rules governing the formation, interpretation and discharge of engineering contracts, and the rights, liabilities and remedies of the parties thereto; including the preparation and criticism of specifications. Mr. CHURCH.

98—WATER-SUPPLY ENGINEERING AND RIVER AND HARBOR IMPROVEMENTS—Rainfall and storage—Flow of streams—Influence of soils, elevation, geological character of water-shed—Methods of supply, gravitation, pumping from rivers or natural underground storage, flow from the latter—Reservoir construction—Distributing system. House supply and wastage. River and Harbor Improvements—Jetty system of river improvements—Scouring action of currents—Erosion of river banks—Dams for improvement of river navigation—Breakwaters—Dykes—Groins—Mattress work—Docks—Harbor works—Iron piers—Estimates of cost. Text-book: *Public Water Supplies,* Turneaure & Russell. 2 hours lectures, recitations, problem and design work. Prof. BLACK. Prereq. 26, 59, 75.

100—Graduation Thesis—A project or thesis on some civil engineering subject, approved by the head of the department, is required of every candidate for the degree of Civil Engineer.

Advanced Courses

The minor subjects in the department of Civil Engineering for the University degrees of Master of Arts and Doctor of Philosophy (those courses which fulfill the residence requirements) are the following:

153-154—ELASTICITY AND RESISTANCE OF MINERALS.

257-258—ELASTIC AND MASONRY ARCHES—Open to those who have taken 57-58. Conferences, reading and design work, as required.

275-276—HYDRAULICS (75 with additional reading).

285-286—FOUNDATIONS, including theory of earth pressure (85 with additional reading).

287-288—LONG SPAN BRIDGES—Open to those who have taken Civil Engineering 87-88. Conferences, with reading and design work as required.

The major subjects for the same University degrees are the following:

259-260—SANITARY ENGINEERING, prerequisites: courses 59, 94, 98.

277-278—HYDRAULIC ENGINEERING, including the hydraulics of rivers and power plants and municipal water-works.

279-280—MUNICIPAL ENGINEERING, including water-works, sewers and sewage works, streets and other public works and their administration.

289-290—THE ENGINEERING OF STRUCTURES, including long span bridges and deep foundations, with methods of building them, and advanced work in Elasticity and Resistance of materials.

ELECTRICAL ENGINEERING

List of Officers

FRANCIS BACON CROCKER, E.M., Ph.D. . . . . *Professor*
GEORGE FRANCIS SEVER, M.Sc. . . . . *Professor*
MORTON ARENDT, E.E. . . . . *Instructor*
——————— . . . . *Tutor*
——————— . . . . *Assistant*
——————— . . . . *Assistant*

For tabular statement of program of studies see pages 21 and 26.

General Statement

The prescribed course leading to the degree of Electrical Engineer (E.E.) requires four years for its completion, and is designed for the education of those who intend to practice the profession of Electrical Engineering, either as engineers, managers, experts in industrial enterprises or as teachers in colleges or technical schools.

The instruction comprises the important branches of theoretical and applied electricity, also the fundamental and collateral subjects, which have been found by experience to be required by the electrical engineer, as, for example, mathematics, physics, chemistry, drawing, mechanical engineering, including boilers, gas producers, engines, turbines, hydraulic developments, transmission devices and shop work, also such general engineering subjects as construction in wood, masonry, iron and steel.

The graduate in Electrical Engineering is accordingly provided not only with a thorough knowledge of the principles and applications of electricity but also with such a broad and liberal education in the allied sciences as will prepare him for the demands likely to be made upon him in connection with the practice of his profession.

The instruction is by lectures and recitations as well as by laboratory, work-shop and drawing-room practice: with periodic visits to the numerous and important electrical factories, power stations and other establishments in and about New York City.

Equipment

The offices, laboratories, museums and lecture rooms of the Electrical Engineering Department are in the southern portion of the Engineering Building. The laboratories located in the basement contain direct and alternating current machinery and apparatus. The smaller machines are mounted upon heavy tables, thus raising them to a convenient

height and affording space for instruments and note-books. To further simplify the work, the machines have been assembled into unit sets, a motor being provided for each dynamo, so that the experimental work of one squad of students is entirely independent of that of other squads.

The direct current laboratory contains constant potential and constant current generators, motor-dynamos, as well as various types of stationary and railway motors, aggregating thirty machines ranging in capacity from 1 to 35 kilowatts and of standard voltages from 115 to 550. Two 10 kilowatt generator sets with a complete switchboard carrying many measuring instruments enable various experiments to be performed by the students on the parallel operation of generators. The constant current equipment includes a dynamo, standard switchboard and series lamp circuits. A working standardization equipment for the calibration of all measuring instruments is installed in this laboratory, and prior to any tests the students are required to check their various instruments. About fifty electrical measuring instruments are employed in this laboratory, comprising ammeters and voltmeters with various scale ranges, also speed indicators, transmission and absorption dynamometers. This laboratory is provided with a set of machine and hand tools employed in the repair of the various pieces of apparatus.

The alternating current apparatus, located in the adjoining room, comprises two single-phase alternators ranging in capacity from 10 to 30 kilowatts and in potential from 104 to 440 volts; two 10 kilowatt synchronous motors and rotary converters operated on single-phase or two-phase circuits; two single-phase and three polyphase induction motors varying in capacity from 1 to 10 horse-power; constant potential transformers of various capacities; phase transformers for converting two-phase to three-phase currents and *vice versa;* a constant current transformer equipment of 5 kilowatts capacity with its control board, circuits and lamps; an induction regulator of 5 kilowatts and a mercury arc rectifier of the same capacity. Each of the various alternators is provided with its own driving motor, so that the speed and frequency may be altered independently. This laboratory equipment includes a complete switchboard for the operation, control, and testing of the rotary converters used as such or as alternators; also a special polyphase circuit measuring board and about thirty instruments for the measurement of alternating voltage, current and power. The alternating current ammeters and voltmeters are of various scale ranges up to 2,000 amperes and 600 volts respectively, also wattmeters up to 1,200 kilowatts range. The instrument equipment further includes several frequency indicators, synchronizers and power factor meters as well as a complete oscillograph and an ondograph for the determination of wave forms, phase relations, etc.

The lecture rooms of the department, capable of seating about 250

students in all, and the museum are located on the first floor of the building. The lecture rooms are provided with direct-current, single-phase and polyphase electrical circuits and projection lanterns so that the lectures may be accompanied by experimental demonstrations and illustrations.

The museum contains many pieces of apparatus and parts of machines used in connection with the lectures, such as specimens of pole line insulators, conduit material, rail sections, rail bonds, insulated cables and materials employed in transmission line and electric railway construction. Also various pieces of apparatus employed in telegraphy and telephony; forms of storage battery plates, samples of products obtained by electro-chemical actions, elementary electrical apparatus, etc.; pieces of electrical machinery, such as armature laminations, field and armature coils, commutator sections, brush holders, brushes, insulating materials; small models of various types of generators and motors; numerous forms of incandescent and arc lamps, lamp mechanisms, carbons and electrodes; lighting arresters, line protecting devices and measuring instruments.

On the third floor of the building are located the large instrument laboratory, the departmental drawing-room and the studies of the officers. The laboratory contains tables upon which the various instruments are permanently set up, ready for use. These include many different forms of galvanometers, two ampere balances with scale ranges from .01 to 100 amperes, two dynamometers with ranges of 1 to 200 amperes respectively, a Standard Weston laboratory voltmeter having a range from .01 to 750 volts and a Standard Weston laboratory millivoltmeter with a set of shunts reading up to 500 amperes, Westinghouse precision watt and volt meters and two very accurate potentiometers. The equipment further comprises apparatus for the exact measurement of resistance, inductance, permeability, hysteresis, and magnetic leakage. This laboratory is supplied with electrical energy from special sources, so that fluctuations do not cause uncertainty in the various measurements. For the direct current work special storage batteries supply potentials up to 250 volts and current capacity of 1,000 ampere-hours. For tests requiring small values of alternating currents a special alternator is operated. This laboratory also contains high tension testing apparatus, consisting of two 50,000 volt transformers of 5 and 10 kilowatts capacity respectively, two 10,000 volt transformers of 5 and 10 kilowatts respectively, and one 5,000 volt transformer of 5 kilowatt output, all designed for operation on 60 cycle circuits, supplied with necessary protective and measuring devices. This instrument laboratory is also equipped with several forms of standard integrating and recording watt-hour meters employed in connection with the standardization of consumers' electric meters for the Department of Water Supply, Gas, and Electricity of the City of New York.

The photometric testing laboratory of this Department is situated in the basement of Havemeyer Hall and is equipped with a Lümmer-Brodhun screen photometer for incandescent lamp testing, a Bunsen screen photometer with a meter prover for gas light testing and a Weber photometer, which is adaptable for arc lamp testing or for the determination of general illumination.

COURSES IN ELECTRICAL ENGINEERING

1—Elements of Electrical Engineering—General Principles of Electricity and Magnetism with examples of their application.

Static Electricity—Production, indications of presence, electroscope and electrometer, law of inverse squares, conductors, electrification by contact and by electrostatic induction, Leyden jars and condensers.

Magnetism—Occurrence in nature, laws of magnetic force, making of permanent magnets, terrestrial magnetism, etc.

Electrical Currents—Work of Galvani and Volta, production of currents, electrical couples and polarity, primary batteries, resistance and conductivity, laws of resistance, Ohm's law, international units of resistance, voltage and current, development of heat by currents, Joule's law, international units of power and energy, incandescent lamps, hot wire instruments and the electric arc.

Electromagnetism—Oersted's discoveries, magnetic effects of electrical currents, galvanometers, dynamometers, voltmeters, ammeters and wattmeters, Faraday's discoveries, electromagnetic induction, its laws and applications, direct and alternating currents, self and mutual induction, unit of inductance, electromagnetic terms, electrodynamic actions, magneto-motive-force, electromagnetic and international units, index notation, flux density, permeability, magnetic and non-magnetic materials, magnetization curves, hysteresis, eddy currents, residual magnetism, magnetic polarity and circulation of currents, electromagnets and polarized mechanisms.

Electrostatics—Potential, electrostatic voltmeters, di-electric capacity, condensers and their use in practice, discharge phenomena and atmospheric electricity.

Electro-chemistry—Conductivity of liquids, electrolysis, laws of chemical action, electro-metallurgy and storage batteries. Text-book: Thompson's *Elementary Lessons in Electricity and Magnetism,* 2 hours per week. Mr. Arendt and Mr. ———. Prereq. Physics 3-4.

2—Elements of the Dynamo—A general consideration of the principles and parts of Dynamo Electric Machinery. History, definition of dynamo and motor, reversibility of functions, magnetic field, magneto-motive-force, hysteresis, elementary dynamo, generation of E.M.F., collector rings and commutator. Parts of the dynamo; the magnetic circuit, materials and function. The armature core: materials, eddy currents, forms, construction. The armature winding: material, function, multiplication of electro-motive-force, types. The commutator: materials and construction. Brushes: function, materials and supports. Field frame: materials, forms, development of magnetic flux, windings, magnetic leakage. Armature reaction: cause of, back and

cross ampere turns, brush shifting, sparking at brushes and remedies. Action of different types of dynamos, and typical forms. Text-book: Crocker's *Electric Lighting,* Vol. I. Two hours per week. Mr. ARENDT. Prereq. Physics 3-4, E. E. 1.

52—DESIGN OF DIRECT CURRENT MACHINERY—Application of electrical and mechanical theory to the design and calculation of D. C. machinery with a complete and original design of a dynamo or motor in accordance with specifications, requiring all calculations, working drawings and blue prints. Text-book: Thompson's *Design of Dynamos.* 2 hours lecture and one afternoon drafting room. Professor SEVER. Prereq. E. E. 1, 2, and 101.

54—DESIGN OF ALTERNATING CURRENT MACHINERY—The application of alternating current theory and practical data to the calculation and design of alternators, transformers, induction motors and other alternating current apparatus. Reference books: Arnold's *Wechselstromtechnik;* Thompson's *Dynamo Electric Machinery,* Vol. II, and McAllister's *Alternating Current Motors.* 2 hours per week. Dr. ———. Prereq. E. E. 52, 103 and 105, Mechanics 108 and 109.

72—DIRECT CURRENT LABORATORY—Short course for students in Civil, Chemical, Sanitary and Mining Engineering, Metallurgy and Chemistry. The experiments cover the following: Fall of Potential, Resistance determinations, Study of various types of D. C. generators, their connections and characteristics of operation. Working of generators in parallel. Study of various types of motors, their connections, characteristics of operation and determination of commercial efficiency by brake tests. The results of these experiments are handed in as reports which are returned promptly to the students, with comments and corrections. Text-book: Sever's *Electrical Engineering Experiments, etc.* 1 afternoon laboratory work. Professor SEVER and Assistants. Prereq. Physics, 3-4, E. E. 1, 2, and 101.

73—DIRECT CURRENT LABORATORY WORK—Short course for students in Mechanical Engineering. Text-book: Sever's *Electrical Engineering Experiments and Tests on Direct Current Machinery.* 1 afternoon laboratory. Professor SEVER and Assistants. Prereq. Physics 3-4, E. E. 1 and 2 with a parallel course E. E. 101.

75—ALTERNATING CURRENT LABORATORY—Short course for Civil, Mining and Mechanical Engineering students. The experiments cover the following: Study of Elementary phenomena of alternating current circuits, with determination of inductance, capacity, impedance, true watts, apparent watts and power factor. Study of an Alternator, its operation, characteristic curves and wave form. Transformers: Their operation and commercial efficiency. Induction motors: Characteristics and efficiency by brake tests. Synchronous motors, their operation under various conditions and characteristic curves. Rotary converters,

operation under various conditions of load and power factor (direct and inverted). Alternators in parallel, division of load and conditions for maximum economy. The student is required to prepare a report upon each experiment which is promptly corrected and returned to him for his instruction. Text-book: Townsend's *Short Course in Alternating Current Testing.* 1 hour lecture and 1 afternoon laboratory practice. Mr. ——— and Assistants. Prereq. E. E. 72 or 73 and 104.

101—DYNAMO AND MOTOR PRACTICE—A course of lectures parallel to and descriptive of D. C. laboratory work. Short circuits and protective devices. Instruments: construction and use. Armature: e. m. f. current, resistance of, voltage drop in, windings and connections. Commutator: function, construction, heating, sparking, collecting brushes and holders. Magnetic circuit: calculation of flux and field windings. Heating of field and armature. Characteristics of the various types of generators and methods of regulation. Motors, theory of action and types. Methods of control and speed regulation. Losses and determination of efficiency by brake, stray power and pumping back methods. Text-books: Crocker's *Electric Lighting,* Vol. I, and Sever-Townsend's *Laboratory and Factory Tests in Electrical Engineering.* 2 hours. Professor SEVER. Prereq. E. E. 1 and 2.

103—ELECTRIC POWER—Electric motors, their action, control and application. Introductory. Classification of work requirements. Shunt Motors: Characteristics, predetermination of action, and efficiency, methods of speed control and regulation, rheostatic, field weakening, multiple voltage, double armature and teaser system. Series Motors: Connections, predetermination of characteristics and efficiency, control: rheostatic, field weakening, double armature and series parallel. Compound motor, characteristics and methods of control. Alternating current motors introductory. Commutator A. C. motors, series and repulsion types, characteristics and control. Synchronous Motors, characteristics and control. Induction Motors, single and polyphase, characteristics, methods of starting, speed control and regulation. Electric Drive, advantages of and application to machine tools, cranes, elevators, presses, pumps, fans, wood working and mill work. 3 hours, Professor CROCKER. Prereq. E. E. 1, 2, 101, 104, 173 and 174.

104—ELECTRIC DISTRIBUTION—Principles and methods of transmitting, distributing and controlling direct and alternating currents. Introductory, Physical properties of conductors, series systems of distribution, parallel systems of distribution, feeders and mains, voltage regulation, three wire systems, high voltage direct current systems, network systems, principles of alternating currents, study of wave shapes, inductance, capacity, phase angle, effective values of electro motive force and current, power factor, resonance, simple circuits, parallel circuits, line inductance and distributed capacity, calculation of single phase circuits and genera-

tion of polyhase currents. Text-book: Crocker's *Electric Lighting,* Vol. II. 3 hours. Professor CROCKER and Mr. ARENDT. Prereq. E. E. **1**, **2**, and **101**.

105—ELECTRIC PLANTS—The design and installation of electric power systems, including translating, controlling and transmitting equipments. Transformers, principles, efficiency, regulation and protection. Constant current transformers principles, regulation and efficiency. Polyphase systems of generation, two phase and three phase, economy of generators, of transmission, and conversion from one system to another. Calculation of alternating current transmission lines, regulation of voltage and power factor of systems. Switch-boards, materials, apparatus used upon, location and types. Line construction, Pole lines, cable and conduit systems. Text-book: Crocker's *Electric Lighting,* Vols. I and II. 2 hours. Mr. ARENDT. Prereq. E. E. **1**, **2**, **101**, **104**.

106—MANAGEMENT OF ELECTRIC PLANTS—Economy of design, construction and operation of electric plants and industrial enterprises. Incandescent and arc lamps, methods of charging for electric power, operating expenses, sources of income, organization and administration of corporations, reports, specifications, contracts, insurance regulations, patents and statistics. 2 hours. Prof. CROCKER and Mr. ARENDT. Prereq. E. E. **103**, **104** and **105**.

110—TELEGRAPHY AND TELEPHONY—The principal methods and instruments employed in telegraphy, telephony and electric signalling. Telegraphy: Historical review, Morse systems, relays and sounders, earth circuits, station equipments, repeaters, differential and polarized relays, duplex systems, quadruplex systems, telegraphy from moving bodies, recording systems, submarine cables and telegraph circuits. Wireless telegraphy: generation of electrical waves, simple transmitting and receiving apparatus, study of different systems. Telephony: Historical review, Bell's work, the magneto-telephone, the microphone and carbon transmitters, use of induction coils, call methods, series and parallel circuits, subscriber's equipment, line disturbances, common battery systems, subscriber's and exchange equipment, party lines, automatic systems, combined telegraphy and telephony. Text-books: Maver's *American Telegraph Practice* and Miller's *American Telephone Practice.* 2 hours. Professor CROCKER and Mr. ARENDT. Prereq. E. E. **104**.

112—ELECTRIC RAILWAY—Special instruction in calculation, installation and operation of electric railway systems. Historical review and early development. Train resistances due to tracks and bearing surfaces, curves, grades, and air. Acceleration and breaking. Speed time curves. Motors for railway work. Controllers. Distribution systems, track construction, bonding and electrolysis. Trucks, wheels and car bodies. Conduit, storage battery and third rail systems. Electric

locomotives and mutiple unit control. Testing railway equipments. Financial considerations. 2 hours. Professor SEVER. Prereq. E. E. 104.

173-174—DIRECT CURRENT LABORATORY—A series of experiments for electrical engineering students in the operation and testing of direct current machinery. The work comprises the following: 1. Practice in the accurate use of voltmeters and ammeters for the measurement of electromotive-force and current. Determination of resistance of the electrical circuits of electrical machinery by "drop," comparison and direct deflection methods. Use of Wheatstone bridge for determination of high resistance. 2. Generators: Preliminary study to bring out relations between, speed, field strength and voltage. Operation of shunt, series and compound-wound generators with determination of characteristic action of each type. Distribution of potential around commutator and distorting effects due to armature reactions. Heat runs to determine load capacity and efficiency determinations by means of stray power and "pumping back" tests. 3. Motors: Function and operation of starting boxes, study of motors, existence and measurement of c.e.m.f., operation of shunt, series, compound and differentially wound motors, determination of speed-load curves of each type. Efficiency tests by brake and stray-power methods. 4. Operation of shunt and compound-wound generators in parallel, methods of connecting, distribution of load, effects of individual differences, etc. 5. Constant Current Dynamos: Comparison of characteristics of constant potential and constant current circuits, methods of governing constant current machines, action under variable loads, control of series circuits, regulation of arc lamps. Text-book: Sever and Townsend's *Factory and Laboratory Tests in Electrical Engineering.* 6 hours. (two afternoons). Professor SEVER and Assistants. Prereq. E. E. 1 and 2. Parallel Course 101.

176—ALTERNATING CURRENT LABORATORY—A series of experiments for electrical engineering students illustrating the fundamental theory and applications of alternating current phenomena. 1. Alternating current circuits: determination of inductance, capacity, impedance, phase relations, true and apparent watts and power factor. 2. Alternators: operation at different power factors, magnetization curves, determination of losses and synchronous impedance, field compounding, etc. 3. Synchronous Motors: Methods of synchronizing, efficiency, action under varying conditions of load and field current. 4. Rotary convertors: Methods of starting, operation direct and inverted, compounding, determination of voltage ratios and calculation of efficiency. 5. Alternators in Parallel: division of load, cross currents and adjustment of excitation for maximum economy. 6. Transformers: operation, determination of losses, regulation, heating and efficiency. Use as in-

duction regulators and phase changers. 7. Wave Forms: determination of wave shapes and phase relations of electromotive-force and current in relative and non-relative circuits as well as in the primary and secondary circuits of transformers by instantaneous contact and oscillograph methods. 8. Resonance: by means of inductance and capacity in series, by inductance and leading current produced by synchronous motors, with application to transmission lines and rotary converter regulation. 9. Induction Motors: methods of starting, characteristic curves, determination of losses and efficiency by brake tests, application of circle diagram and use as frequency changer. 10. Induction Generator: operation and determination of the external characteristic. Text-book: Sever and Townsend's *Factory and Laboratory Tests in Electrical Engineering.* 9 hours (3 afternoons). Dr. ——— and Assistants. Prereq. E. E. 103, 104 and 173-174. Mechanics, 109.

177—INSTRUMENT LABORATORY—Calibrating of commercial measuring instruments and advanced electrical measurements, as follows: 1. Calibration of ammeters by comparison with laboratory standards, Kelvin balances, Siemens' dynamometers, and potentiometers. 2. Calibration of voltmeters. 3. Calibration, adjustment and determination of constants of A. C. and D. C. watt-hour meters, by various methods. 4. Determination of resistances: by Wheatstone bridge and potentiometer methods. 5. Measurements of Inductance and capacity. a. By comparison with standards using A. C. bridge. b. By absolute method, including determination of constants of ballistic galvanometer. 6. Magnetic measurements. Determination of coefficient of magnetic leakage of generator or motor. Determination of the permeability of samples of iron and steel. a. By Hopkinson's method. b. By Ewing double bridge method. c. A. C. voltmeter method. d. Direct reading voltmeter method. Determination of Hysteresis by Hopkinson, Double bridge, Voltmeter and Ewing tester methods. 7. Storage Battery Testing. Determination of normal rate of discharge, capacity and efficiency at normal rates, capacity at various rates. Constant current and constant potential methods of charging, weight efficiency and losses on standing. 8. Photometry. a. Proving gas meters and determination of candle power of gas against standard candles. b. Candle power incandescent lamps using standard candle. c. Distribution of light from an incandescent lamp, using secondary standard. d. Determination of mean spherical and mean hemispherical candle power of an incandescent lamp. e. Relations between voltage, candle power, efficiency and life of incandescent lamps. Arc lamp photometry. 9. Cable Testing. a. To determine insulation resistance; induction and capacity. b. To determine location of faults. Text-book: Sever and Townsend's *Factory and Laboratory Tests in Electrical Engineering.* 1 hour lecture and 3 afternoon's laboratory work. Professor SEVER and Assistants. Prereq. E. E. 173-174.

Graduate Courses

101, 104 and 173-174—DYNAMO AND MOTOR PRACTICE, ELECTRICAL DISTRIBUTION AND D. C. ELECTRICAL LABORATORY—2 hours and 5 hours laboratory. Prerequisites: Courses 1 and 2, 103, 105, 106, 176 and 177. Electric Power, Electric Plants, Management of Plants and Electrical Laboratory. 3 hours and 2 afternoons laboratory. Prerequisites Courses 101, 104, 173-174.

176—ALTERNATING CURRENT LABORATORY—with Mechanics 109 and 110. 3 hours first half year, 2 hours second half year and 3 afternoons second term. Prerequisites E. E. 104, 173-174 and Mechanics 108, 201, 202. Special Problems and Original investigations in Advanced Electrical Engineering, with conferences and laboratory work as required. Prerequisites, all courses for the degree of Electrical Engineer.

NOTE—Attention is called to the advanced theoretical courses offered by Professor Pupin in the Department of Mathematical Physics. (See page 117.)

MECHANICAL ENGINEERING

List of Officers

Charles E. Lucke, M.S., Ph.D. . . . . *Professor*
Walter Rautenstrauch, M.S. . . . . *Professor*
James M. Dodge, M.E. . . . . *Associate*
Harry L. Parr, A.B., M.E. . . . . *Instructor*
Charles W. Thomas, M.E. . . . . *Tutor*
Louis Doelling . . . . *Lecturer*
Richard T. Lingley, C.P.A. . . . . *Lecturer*
Frederick W. O'Neil, M.E. . . . . *Lecturer*
Frederick Ophuls, M.E. . . . . *Lecturer*
William H. White, B.E. . . . . *Lecturer*
Edward D. Thurston, Jr., A.B., M.E. . . . . *Assistant*

For tabular statement of program of studies see pages 21 and 30.

General Statement

The regular four-year course, leading to the degree of Mechanical Engineer, offers a thorough basic training in the design, construction, manufacture and operation of all classes of standard and special machinery, mills, shops, factories and power plants, as well as in the technical and executive management of the dependent industries. To this end the course of instruction is as broad as is consistent with the directness of its purpose. The Mechanical Engineer must not only be grounded in the fundamental scientific basis of his profession, and so trained as to be capable of applying this to both the technical and commercial aspects of industrial problems, but his immediate usefulness upon graduation demands that a considerable portion of the instruction be concerned with the practical application of the principles taught.

The course begins with a thorough training in mathematics, physics and chemistry as a foundation for the appropriate technical work, which is developed along several parallel lines. Applications of these fundamental sciences to the physical properties of the materials of construction, especially the metals and their practical manipulation, lead through the courses in metallurgy, mechanics, resistance of materials, shop processes, the materials testing laboratory, drafting and kinematics to the principles of design, which are fixed by application to the design of special machinery for the execution of any specified manufacturing proc-

ess and to certain standard machinery, such as steam and gas engines and turbine water wheels. The principles underlying the performance of machinery are developed by courses in thermodynamics, mechanics and hydraulics and the experimental laboratory and are fixed by analysis of machinery for steam and gas power, pumping, compressing, refrigerating, mechanical handling of materials and their most important applications. The instruction in the performance, design and manufacture of machines and power units in the class-room and laboratory, supplemented by frequent visits to power plants and factories, is the basis of the work on the design of plants and mills.

Throughout the instruction the student is thrown as much as possible on his own resources, encouraged to use such knowledge as he possesses, to read standard authorities and to make comparisons between the existing data on various subjects and with the results of theoretical computations. In the experimental work special stress is laid upon this as a means for the development of that initiative, executive ability and spirit of investigation so necessary for the successful practice of the profession, which is one long series of new problems demanding solution. The commercial and industrial phases of the technical subjects are dwelt upon throughout the entire course of instruction, and particular attention is given to labor and cost systems, works management, economy of manufacture and of power generation, economics and industrial law.

To insure a close contact between the work of the department and the practice of the profession, recognized experts are invited to conduct courses on their particular subjects, the regular officers of the department attending and subsequently holding recitations and examinations. In accordance with this policy the following mechanical engineers will give courses in their respective subjects in the year 1908-1909: James M. Dodge, founder and head of the United Link Belt Companies, on the mechanical handling of materials; Wm. P. White, Chief Hydraulic Engineer of the I. P. Morris Co., on turbine water wheels; Fred Ophuls, Manager of the De La Vergne Machine Co., on refrigerating and ice-making machinery; Fred W. O'Neil, New York Manager of the Nordberg Mfg. Co., on air machinery; Richard T. Lingley, certified public accountant, on works accounting; Messrs. Dodge & Day, on manufacturing plant design; Louis Doelling, Vice-President of Schutte & Koerting Co., on steam jet apparatus.

This list of special lecturers conducting courses is incomplete at the time of this announcement, but when completed will include courses on pumping machinery, works management, steam turbines, power plant design, shop processes and manufacturing plant design. In addition to the above, a list of non-resident lecturers, who deliver one or more lectures to the students on the work in their respective engineering fields will be found on page 7.

The overlapping of the Mechanical Engineering and Electrical Engineering professions makes it desirable that the Mechanical Engineer shall be thoroughly conversant with the ordinary problems of the Electrical Engineer in the generation and distribution of electric current, the characteristics of electrical machinery, and the design and installation of electrical plants. To this end students in this course receive instruction in the department of Electrical Engineering covering these subjects.

Graduate work in Mechanical Engineering is offered to students who have successfully completed the undergraduate course. This graduate work includes the more difficult applications of mechanics and thermodynamics to questions of engineering, as well as special investigations in design, experimental research, and the development of new processes of manufacture. Special students are admitted to any of the courses upon evidence of proper qualifications. Courses are also offered to students in other departments covering such instruction in Mechanical Engineering as may properly assist in the practice of their respective professions.

Equipment

Besides the usual offices, lecture rooms, drawing rooms and museum, the department is unusually well equipped with experimental laboratory facilities. These laboratories cover a floor space of some 12,000 sq. ft. and contain apparatus valued roughly at $75,000. A fairly full line of instruments for making simple measurements is always available for regular student work, and includes thermometers, pyrometers, barometers, simple and differential manometers, draft gauges, speed counters, tachometers, angular velocity meters, planimeters, Pitot tubes, water meters, piston, rotary and Venturi type, hook gauges, steam and gas meters, steam, gas, coal and oil calorimeters, flue gas analysis apparatus, scales for weighing and measuring, transmission dynamometers, Prony brakes, indicators of all types, pressure and vacuum gauges, anemometers, mercury columns, and calibrating apparatus for all instruments. Besides these measuring devices there is a large number of pieces of special apparatus for various purposes, such as the testing of carburetors, pressures due to explosion of gas mixtures, rate of propagation of explosive mixtures, pressure and temperatures of vaporization of liquid fuels, loss of head in steam, air and water pipes, condensation of steam in pipes, bare and covered, flow of steam or water through orifices and turbine nozzles, capacity of steam traps, flash, chill, density, viscosity and carbonization of oils, friction of bearings, losses in power transmission. These various instruments and pieces of special apparatus are grouped and used in connection with a considerable number of machines of standard form. These include a standard gauge Vauclain compound locomotive, mounted on friction wheels equipped with dynamometers. This locomotive is so erected that it can be operated with

its own steam, line steam or compressed air, the exhaust passing through an induced draft fan separately driven by a small steam engine. A Reynolds Allis-Corliss triple expansion engine, double eccentric type, is equipped to operate condensing and non-condensing, and is fitted with reheating receivers and may be operated with line steam or high pressure steam from the locomotive boiler. This Corliss engine has a tandem connection to three air cylinders, equipped with Gutermuth flap valves, operating three-stage with water intercoolers. A cross compound steam, two-stage air compressor of the Ingersoll-Sargent type operates in parallel with the other air compressor and a Westinghouse simple air pump with complete air brake equipment. There is also a belt driven and a steam fan for fan investigations. Besides the steam engines mentioned there are also a Westinghouse two-cylinder, single-acting; McIntosh and Seymour automatic; Sweet straight-line simple engine, besides some smaller reciprocating units, and a De Laval steam turbine, all piped to condensers for efficiency tests. A Foster superheater separately fired in connection with three surface condensers, Wheeler, Worthington, Allis, each with its own air and circulating pumps, adds considerably to the steam equipment, which includes also typical injectors, steam traps, feed water heaters, steam separators, reducing valves, safety valves, back pressure valves and other ordinary steam auxiliaries and specialties. The hydraulic work is well provided for by two large 20,000-lb. measuring tanks, fitted with swinging guide-bucket for continuous flow measurements, receiving the discharge from all the hydraulic apparatus; water channels of rectangular, trapezoidal and triangular cross section, rectangular and trapezoidal weirs, fitted to two weir tanks, one iron, the other wood, three impulse water wheels, one small turbine, hydraulic rams, simple, single and duplex steam pumps, direct acting and flywheel, compound Blake pump, single acting, direct acting triple expansion duplex, low pressure Worthington pump of large capacity and low head, separately steam driven centrifugal Lawrence pump, belt driven centrifugal pump, a high pressure pump and accumulator of the Worthington type for 1500 lbs., and a second for 5000 lbs. pressure. Two hot air engines, and several internal combustion engines, including the Nash, fitted to operate on various fuels, a Hornsby-Akroyd and a Mietz and Weiss oil engine, an old and a new style Otto, an International Harvester, a Daimler boat engine are equipped for gas engine test and investigation work of great variety. From time to time engines of this class are secured for short periods of time for testing purposes. For the study of refrigeration there is installed a small Brunswick ammonia compression ice-making and refrigerating unit, motor driven, and a larger De La Vergne steam-driven, ice-making plant.

COURSES IN MECHANICAL ENGINEERING

11-12—Steam Power Machinery—Functions, Forms and Principles of Operation of the Typical Steam Power Plant Units, Auxiliaries and Connecting Elements. Methods of receiving, storing and firing coal, coal handling machinery, grates, stokers and furnaces for the combustion of coal; smokeless combustion and smoke ordinances; flow of gases through boilers, flues, dampers and the generation of necessary draft by chimneys, fans and steam jets. The construction and operation of boilers, boiler settings and foundations. Methods and apparatus for feeding water to boilers, necessary boiler attachments and trimmings. Flow of steam from boilers to engines and the grouping of engines and boilers, piping, valves, fittings and pipe covering. The heating of boiler feed water in feed water heaters and economizers. Purification of boiler feed water and effects of impure water on the boiler. Boiler strength tests and inspection laws. Boiler explosions. Steam pipe condensation and drainage. Steam traps, separators, steam superheating and superheaters. Condensing operation of steam engines by jet, surface, ejector and barometric condensers. Necessity for and types of circulating, hot-well and dry vacuum pumps and cooling towers. Typical steam engines and the variations in form and character of their important parts. Engine valves of simple and complete form, relation between construction of engine and valve gear to its economy. Special valve gears for high economy, for reversing and for power control. Regulation of engines and engine governors. Relation between engine construction, foundations, vibrations and balancing. Steam turbines. Typical steam plant arrangements for various special and standard conditions.

Afternoon work in laboratory, power house and drafting room, sketching apparatus, setting valves, plotting diagrams and demonstration of principles of operation taught in class. Time, three hours per week for year and one afternoon per week in the second term. Professor Lucke, Mr. Parr and Mr. Thurston. Second year Mechanical Engineering. Prerequisite course: Physics 3, 4; Chemistry 3, 4.

13-14—Steam Power Machinery—Short course adapted from M. E. 11-12. Professor Lucke. Three hours per week. Second year Civil and Electrical; Third year Metallurgical, Chemical, and Mining Engineering; Fourth year Chemical.

17-18—Technical Thermodynamics—Laws of Heat Generation by Combustion, Heat Transfer and Transformation into Work. Relation between temperatures and quantities of heat. Units of heat. Effect of heat on solids, liquids, gases and vapors. Laws of heat transfer. Laws of surface evaporation, ebullition and condensation. Properties of saturated and superheated vapors. Combustion of fuels, calorific power, quantities of air for combustion. Temperature of combustion. Boiler efficiency and

conditions affecting. Principles of chimney draft. Laws of expansion and compression of gases. Work and heat diagrams to pressure volumes and temperature entropy co-ordinates. Air and wet vapor compression. Expansion of steam by hypothetic, adiabatic and saturation laws and application to steam engine efficiency. Missing water in steam engines. Influence of cylinder condensation, re-evaporation, steam jackets, initial superheat, compounding and reheating on steam engine efficiency. Relation of boiler and engine performance. Free expansion laws and application to injector and steam turbine nozzles. Heat transformation by perfect gases. Hot air, gas and oil engine efficiency. Mechanical refrigeration. Effects of evaporation of ammonia and carbonic acid and expansion of air. Heat balances and combined efficiency of complex systems. Professor LUCKE. Third year Mechanical, Electrical, and Civil Engineering; Fourth year Chemical Engineering; Third year Mining Engineering for first term. Prerequisite courses: Mechanics 102; M. E. 11-12 or 13-14; Chem. 81-82; Mechanics 106 for second term part and M. E. 31 second term part for Mechanical Engineering.

19—ENGINE DESIGN—Advanced Machine Design Based on the Thermal and Mechanical Problems Involved in the Design of a Steam Engine for Power, Economy and Regulation. Determination of ideal indicator card, probable M.E.P., piston speed, R.P.M., and displacement for required power, selection of single or multiple expansion construction from economy requirements, limits of clearance, cutoff, release, compression and admission for type of valve gear selected. Stresses due to steam and inertia in the principal parts. Forms and proportions of the parts determined by intensity, distribution and nature of the stresses, properties of the materials and conditions affecting maintenance. Determination of proportions of engine parts. Design of flywheels for limiting variation in velocity and analysis of resulting angular variation. Balancing the engine. Valve gears and governors, determination of the proportions of the valve for predetermined steam distribution, analysis of valve movements and moving gear. Graphic representation of the simultaneous events of valve opening, steam velocities and piston velocities. Analysis for the effect of the angularity of the rod. Equalizing the events of the valve. Analysis of the characteristics of the shifting eccentrics and the resultant variations in the valve events. Layout of the Corliss valve gear with single and double eccentric, and proportions of the mechanism. Steam engine governors, flyball and shaft governors, limits of movement, valve gear resistance. Proportions of the governor. Professor RAUTENSTRAUCH and Mr. THOMAS. 6 hours and 4 afternoons. Fourth year Mechanical Engineering. Prerequisite courses: M. E. 39, 40, 11, 12, 54.

22—GAS POWER MACHINERY—Theoretical and Practical Consideration Affecting the Generation of Power by Gas Engines, Including

Oil Vaporization, Coal Gasification and the Design of the Machinery. Efficiency, M.E.P., displacement per minute per I.H.P. for reference diagrams. Limitations of external and internal heating. Methods of explosive and non-explosive internal heating. Properties of explosive gas mixtures, air necessary, calorific power per cu. ft. of mixture; temperature of combustion, heat suppression, efficiency of combustion, pressure and volume effects, limitations of proportions, temperature of ignition, rate of propagation, the explosive wave. Critical examination of modern gas engine forms and functions of parts; means for mixing and proportioning, pressure regulators, ignition; governors, effects on the engine and mechanism; starting equipment; exhaust piping and muffling; effects of back pressure in the engine; cooling; preignition, effect of cooling on economy. Large blast furnace practice, methods of gas cleaning; blast furnace gas, quality. Large engine construction, and forms of parts. Producer gas practice; standard producer for anthracite and bituminous coal, characteristics; gas, variation in quality, effects on the engine; methods of blasting producers, auxiliary steam supply and steam consumption; efficiency and rate of combustion in producer; scrubbers and tar extractors. Carburetors and vaporizers for liquid fuel; petroleum distillates, crude oil and denatured alcohol, vapor tension curves for liquid fuels. Characteristics of modern forms of gasoline and oil engines, gas power plant arrangements, producer engines, their efficiency, coal consumption and comparison with steam plants.

Complete analysis of the rating, efficiency, regulation, forces acting in and strength of parts of a modern gas engine. Probable indicator card, inertia of reciprocating parts, wrist pin and turning effort diagram. Dimensions of all parts. Professor Lucke and Mr. Parr. 4 hours and 1 afternoon. Fourth year Mechanical Engineering. Prerequisite courses: M. E. 19, 33.

26—Steam Power Plant Design—Relation Between the Cost of Power and Thermal Efficiency of the Plant. Commercial Value of Refinements. Determination of engine and boiler ratings and corresponding efficiencies and probable coal and water consumption for plant on given load curve. Essential relation between processes and dimensions of the steam plant. Steam plant refinements for raising efficiency of part or complete plant and relations between dimensions and effect. Use of unit costs of apparatus in estimating, examination of cost sheets to determine prime unit of cost. Cost of power. Fixed and operating charges, ratio of each individual item to total and effect of labor and fuel rates, load factor and refinements on the fractional part. Value of refinements of design on basis of capitalized annual saving by comparing the cost of waste and the cost of its elimination, including all charges. Specifications and contracts; standard and special methods and forms for defining purchaser's requirements and builder's pro-

posals, contracts, methods of power plant erection. Designing and erecting office organization and field systems.

The work consists in laying out a simple power plant for assigned units in the drafting room or the detailing of existing general plant drawings, preparation of the bill of materials, estimating the first cost, fixed charges, probable coal, water, labor and supply cost for an assumed load curve and total power cost. The plants so designed or detailed are exchanged by students and redesigned for an increase of 100 per cent. peak and 50 per cent. mean daily load and for the maximum power cost reduction by the use of plant refinements and auxiliaries when it can be shown that additions and alterations will pay. Specifications are written for the alteration and proposals submitted. Professor LUCKE and Mr. THOMAS. 3 hours and 3 afternoons. Fourth year Mechanical Engineering. Prerequisites: M. E. 53, 33, must parallel International Law and *Economics 1.

31-32—EXPERIMENTAL ENGINEERING—Laboratory methods for the determination of experimental data. Derivation of physical laws from experimental results. Comparison of actual performance of machines with computed prediction and evaluation of unknown elements. Methods of approach for the solution of practical problems by experiment and computation. The work is illustrated by problems on the flow of liquids, gases and vapors, combustion, transfer of heat, steam generation and changes of state, transformation of energy, power generation and transmission, energy losses, thermal, hydraulic and mechanical. For each problem a preliminary report is submitted before the test, involving the analysis of the problem, the attempted prediction and the required test log, based on class-room explanations; this is incorporated with the tests results and an interpretation of differences between these and the prediction, including judgment of errors, to constitute the final report. The apparatus for this course includes: Pressure gauges, manometers, thermometers, pyrometers, indicators, tachometers, planimeters, barometers, weirs, channels, nozzles and orifices for water, steam and air, Pitot and Venturi tubes, steam, gas and water piping and meters, dynamometers, power scales, viscosimeters, flue gas apparatus, steam traps, hydraulic ram, steam injectors, air pump, hot air engine, duplex steam pumps, Pelton wheel, centrifugal pump, simple steam engine. Mr. PARR and Mr. THURSTON. One hour and one afternoon. Third year Mechanical Engineering. Prerequisite courses: M. E. 11-12. Courses which are to parallel it: M. E. 17-18 and Mechanics 106.

33—EXPERIMENTAL ENGINEERING (Continuation of course 31-32)—The work of this course is the same in nature as 31-32, but the problems involve more difficult computations and more skilful manipulation of the apparatus. These problems are principally concerned with energy

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transformation, necessary and accidental losses and the determination of the conditions affecting performance of compound and triple expansion steam engines and pumps, operating condensing and non-condensing, with and without receivers, with and without reheaters. Hydraulic motors, gas and oil engines, one, two and three stage air compressors, with and without intercoolers, feed water heaters, fans, steam boilers, ammonia refrigerating machines, steam superheaters and condensers. Attention is also given to the commercial tests standardized by the Engineering Societies. Mr. Parr and Mr. Thurston. Fourth year Mechanical Engineering. 2 hours and 1 afternoon. Prerequisite courses: M. E. **31-32**; M. E. **96S**; M. E. **17-18**.

36—Kinematics of Machinery—Determination of Paths of Motion, Velocity, Acceleration and Kinetic Forces of the Moving Parts of Machines with the Resulting Reaction Forces of the Frame. Relative motions of machine parts and the determination of the rates of motion. Determination of space, velocity and acceleration diagrams with application to the steam engine, shaper and other standard mechanisms. Construction and use of diagrams for the determination of inertia forces and their distribution in each element of a machine. The layout of motions to specifications. Design of cams with special reference to the rate of change of velocity of the moving parts and the resultant inertia forces, resistances to motion and the continuous contact of cam and follower. Analysis of link work, relative motions, inversions, adaptability to the accomplishment of specific kinds and limits of motion. Eccentrics and links for the transformation of kinds of motion; ratchet motions; running ratchets. Clutch and coupling mechanisms, connecting shafts in parallel and at an angle. Modification to permit of non-alignment. Toothed gearings. Justification of the cycloidal and involute curves in their application to gear teeth. The layout of tooth forms and the determination of the velocity ratios. Layout of bevel gear tooth forms by Tredgold's method. Approximate methods and practical rules for the layout of gear teeth. Determination of paths of contact, obliquity of motion, length of teeth, interferences in involute gearing with connections. Determination of the necessary conditions for interchangeability in sets of cycloidal and involute gears and comparison of the system. Friction gears. Kinematics of belt drive. Open and crossed belts. Layout of belt drives and guide pulleys. Kinematics of sprocket wheels and chain drives and guide pulleys. Kinematics of sprocket wheels and chain drives, rope drive; speed changing devices using wrapping connections. Layout of chain gearing for short centers and positive drives. Professor Rautenstrauch. Two afternoons. Second year Mechanical and third year Electrical Engineering. Prerequisite courses are Math. 5 and M. E. 59.

39—Principles of Machine Design—Analysis of the Stresses in Machine Parts of Standard Form under Varying Conditions of Service

and the Proportioning of the Machine Elements to Safely Resist the Resulting Stresses. Selection of working stresses for machine parts subjected to steady, repeated and reversed strains. Design of machine parts for the flexural and torsional stiffness and wear. Selection of materials for machine parts, based on their adaptability to the service and to the shop process by which the part must be made. Determination of the proportions of shafts, gear wheels, pulley and flywheels, springs, riveted joints, braces, stays, bolts and other fastenings, flat plates, friction and pressure joints, long column members, thin cylinders, flues and tubes subjected to internal and collapsing pressures, screws, belts, ropes and chains for power transmission. Analysis of experiments on the lubrication of bearing surface. Proportions of plain cylindrical and sliding bearings, ball roller, pivot and thrust bearings, limiting pressures, speeds, adjustment and methods of lubrication. Straining actions in machine frames. Application of the theory of elasticity, the design of thick cylinders, curved members, as disks and turbine wheels. Professor RAUTENSTRAUCH. 1 hour and 2 afternoons. Third year M. E., Fourth year Chemical Engineering.

40—MACHINE DESIGN—(Continuation of M. E. 39.) Application of the Principles of Kinematics, Resistance of Materials, Design of the Machine Elements, Shop and Foundry Methods to the Design of Complete Machines. Analytic and synthetic treatment. Analysis of machines to determine the nature and distribution of the forces acting on and the resulting strains in each element due to kinetic, structural and working conditions. The grouping of the elements of a machine for functional operation, erection, adjustment, maintenance and repair and the modifications demanded by the facilities for manufacture. The design of machines for specified performance for which there is required the layout of the motions and the clothing of the same in metal. Analysis of energy cycle and determination of the parts for functional operation, determination of the material to be used for each part. Design of the parts for strength, stiffness and wear, adjustment, maintenance, repair and appearance, interchangeability, proper clearance, erection, shop processes of manufacture and minimum shop cost. Modern requirements in the design of machine tools. Professor RAUTENSTRAUCH. Third year Mechanical Engineering. Prerequisite course is M. E. 39.

41—MACHINE DESIGN—A short course adapted from M. E. 39-40. Professor RAUTENSTRAUCH. First, 1 hour and 1 afternoon. Fourth year Civil and third year Electrical Engineering.

46—WATER POWER MACHINERY—Principles of Design and Economy of Operation of Turbine Wheels and Water Power Plants. Action of water on curved vanes, forces developed and effect of impact, work done; centrifugal action. Theory of reaction turbines. Vane form

and arrangement; total work done for axial, radial and mixed flow wheels; dependence of velocity of flow on speed of rotation; losses of energy due to friction in guide passages, wheel buckets and sluice, shock, leakage, residual velocity. Design of reaction turbines; relation between pressure and velocity of flow; methods of determining passage areas; radii of wheels, width and depth of buckets, number and thickness of vanes. Axial turbines, characteristics, forms and dimensions. Impulse turbines; essential principles and theory, advantages, ventilation of bucket, velocity of flow, available energy, efficiency. Axial impulse turbines, characteristics, forms and dimensions. Centrifugal action in axial flow, reaction and impulse turbines. Radial impulse turbines, inward and outward flow; forms, characteristics and dimensions. Descriptions of and experiments with turbines of various types. Existing water power plants. Modern governors for turbines; ideal action of direct acting governor and disturbing influences; essential principle of indirect acting governor; factors affecting regulation. Mr. WHITE and Mr. PARR. Three hours. Fourth year Mechanical Engineering and Fourth year Civil Engineering. Prerequisite courses: M. E. 53; C. E. 78; M. E. 33.

52—WORKS MANAGEMENT—Manufacturing Organizations and Methods of Accounting. Effect of methods of manufacture and capacity on systems of management of mills and factories. Analysis of the elements of factory accounting and determination of the factors entering into the cost of production. Methods for keeping record of the cost of labor and materials in the production of specific articles. The determination of establishment charges. Interpretation of costs and use of comparative values. Determination of costs and use of comparative values. Determination of the depreciation of buildings, machinery, patterns, drawings and other assets. Organization and functions of the departments of the business. Purchase of raw material and sale of product. Utilization of scrap and waste. Methods of labor compensation. Critical analysis of the methods of accounting in representative factories. Factors affecting the cost of production. Layout of complete system of organization, forms, methods of accounting and progress of work for the factory designed in course M. E. 68, Manufacturing Plant Design. Professor RAUTENSTRAUCH and Mr. LINGLEY. Two hours. Fourth year Mechanical Engineering. Prerequisite courses are M. E. 19, must parallel M. E. 68, Industrial Law and *Economics 1.

53—STEAM TURBINES—Fundamental Analysis of the Action of Steam Jets Impinging on Buckets and Its Application to the Design and Performance of Steam Turbines. Ratio of impulse to reactive force jets, effect of variation of curvature of the buckets, open and closed

*See *Announcement of Columbia College.*

passages. Flow of steam through nozzles and turbine passages, volume, pressure, temperature, quality, weight, velocity and kinetic energy relations. Centrifugal effect of steam moving in a curved path. Study of the use of steam in varying types of turbines. Graded pressure turbines, graded velocity turbines, mixed impulse and reaction turbines. Practical turbines belonging to these types, and study of their detailed construction. Efficiency of different types studied by analysis of energy transformation throughout the path of steam and how efficiency is varied by design of blades, passages, nozzles, number of stages, speed, clearance, leakage and mode of regulation. Construction of turbine vanes. Disc and vane friction and critical speed. Governing steam turbines, throttling method, variable admission to one or more stages and periodic admission. Steam consumption of turbines. Mr. PARR. Two hours. Fourth year Mechanical Engineering. Prerequisite courses: M. E. 17-18, 31-32.

54—PRINCIPLES OF MACHINE MANUFACTURE—The Economic Elements in Shop Processes, Time and Power per Unit of Surface Finished or Cut and per Unit of Metal Removed with the Conditions for Most Economic Production. Processes in the shop, functional operation of machine tools and limits of economic production, time of setting, handling, forming and finishing of parts for job and repetition work in quantity. Limits of time, power and cost for finishing surfaces per sq. in. and removing per cu. in. and per lb. by hand and machine operations. Machines for performing specific operations, their functional operation, capacities, adaptability and rate of production. Conditions warranting jigs and fixtures for the production of parts in quantity and for interchangeability. Economy of portable tools, devices and methods of inspection. The selection of economic cutting conditions and analysis of recent experiments. Adaptation of economic cutting speeds to machine tools. Labor-saving devices in the pattern shop, tools and appliances used, capacity and adaptability; built-up patterns, single-piece patterns, metal patterns, comparative cost and life of each; patterns for repetition work, rights and lefts, a line of sizes, interchangeable patterns, jobbing patterns, relative economy of alternative practice. Economic production in the foundry, relative value of various methods of molding large and small parts, core making, venting, pouring and handling the work, managing the cupola. Limits of labor, power and fuel per ton of castings as affected by size and form and fraction chargeable to pattern, molding and cupola and finishing. Processes of forging, relative of hand and machine forging, conditions warranting power hammers, hydraulic presses, bull-dozers, presses, dies and forming devices for the production of duplicate and standard pieces. Labor and power per lb. of forging as affected by tools, size and form of work. Heating and annealing furnaces, consumption of gas and oil, labor, power and fuel per unit annealed. Distribution of

cost of machine production between different processes, power, labor, material and effect of shop or tool capacity factor on fixed charges. Professor RAUTENSTRAUCH. Third year Mechanical Engineering. Prerequisite courses are M. E. 94S, T. C. Shopwork and M. E. 39.

56—WATER POWER INSTALLATIONS—Selection and Arrangement of Water Wheels, Governors and Auxiliary Appliances for Different Local Conditions, Efficiency of Wheels and Plants. Characteristic of water flow through turbine guides, nozzles and buckets, conditions warranting wheel classification, efficiency of wheels as a function of type, head, speed and part gate operation, effects of different forms of gate on efficiency, relative value of standard patterns and special designs to suit local conditions, limits of standard dynamo speeds on wheel speeds. Water wheel governors regulation. Available head at wheels and division of total loss throughout water conductor system, relation between available water supply, possible output and perfection of development work; draft tubes, stop valves, gates, vacuum and pressure relief stand pipes, relief valves and bye-passes, water racks, anchor and frazil ice. Analysis of typical installations. Water power costs. Professor LUCKE. One hour. Fourth year Electrical Engineering. Prerequisite course: C. E. 76. Parallel course: M. E. 60.

59—EMPIRIC DESIGN—Proportioning of Machine Parts by Empiric Methods and the Production of Shop Drawings and Sketches. Modern practice in making, recording and filing shop drawings of machine details and assemblies, bills of material and listing of standard and special parts. Use of standard conventions and interpretation of shop notes on drawings. Shop sketches and dimensions. Forms of machine parts as indicated by the nature of the resistances to be overcome and the characteristics of the material. Plain, box, and ribbed cast sections, shrinkage stresses and the probability of local weaknesses. Proportions of parts by modern empirical formulas derived from practical considerations. Limiting conditions in the use of empirical formulas. Modern practice in the proportioning of machine elements. Proportions of parts adopted by the Master Car Builders' Association, Master Steam Boiler Makers Association, United States Government, numerous manufacturing concerns and data appearing the transactions of the various engineering societies and engineering publications. Design of simple castings from assigned data, dies for forming simple parts in a bull-dozer and the frames and parts of simple machines having given the detailed drawing of the other parts necessary to the determination of the principal dimensions. Professor RAUTENSTRAUCH. Second year Mechanical Engineering and third year Chemical Engineering. The prerequisite courses are Drafting 1 or 2 and 3 or 4, and Math. 2 and 3-4.

60—HYDRAULIC LABORATORY—Practical Work on the Flowing of

Water for the Determination of Rational Coefficients with Ordinary and Extraordinary Conditions. Flow through simple holes in plate and short tubes under low heads. Flow through convergent nozzles and needle orifice. Flow through straight pipe, elbows and joints, distribution across the cross section near bends with velocity. Flow through open channels. Flow of weirs. Variation of rectangular, trapezoidal and triangular, sharp versus dull edge, approach contractions, one side, both sides and bottom. Hook gauge measurements. Measurement of quantity flowing by Venturi tube and Pitot tube. Variation of error with type, pressure drop and size. Loss of heads by sudden enlargement in cross section in pipes running full. Inertia and water shock. Water wheels. Variation of efficiency with speed and head, analysis of losses in nozzles, bucket and friction. Mr. PARR, assisted by Mr. THURSTON. Third year Mining Engineering, Fourth year Electrical Engineering and Civil Engineering. Parallel courses: Theoretical Hydraulics, C. E. 75 or 76, or 77 or 78.

61—SEMINAR—Discussion by students of current topics in mechanical engineering practice, drawn from the Transactions of the American Society of Mechanical Engineers and from selected journals. Papers are assigned for critical analysis and report which are read and discussed in class as in professional society meetings. Professor LUCKE. One hour. Fourth year Mechanical Engineering. Prerequisite courses: M. E. 17-18, 31-32.

62—REFRIGERATION MACHINERY—Relative Equipment, Space Occupied, Fuel and Water Consumption per Ton of Refrigeration or of Manufactured Ice for Principal Systems. Physical properties of anhydrous ammonia, carbonic acid, aqua ammonia, sodium and calcium brine solutions. Ammonia compression systems, wet and dry and oil injection systems. Liquid storage, pressure and liquid receiver tanks, pipe and fittings, expansion valves, direct expansion coils, double pipe, submerged and shell brine coolers, insulation of tanks and pipes, brine circulating pumps. Compressors. Ammonia condensers, atmospheric, double pipe and submerged, condenser water cooling towers, ammonia fore-coolers and oil coolers for oil system. Carbonic acid systems, characteristics and quantities compared with anhydrous ammonia. Ammonia absorption systems. Absorber constructions, generator construction. Dense air systems. Air drying. Refrigerating rooms, brewery, meat, general stores, restaurants. Ice making. Can and plate systems, water purification systems, oil separators, steam condensers, reboilers, evaporators, single and multiple effect, skimmers, water storage tank and governors. Quantity of water per ton of ice, quantity of steam condensed from compressor and auxiliaries, available and make-up water. Professor LUCKE and Mr. OPHULS. Third year Mechanical Engineering. Prerequisite courses: M. E. 11-12, 17; Mechanics 106. Parallel courses: M. E. 18, 64.

63—HYDRAULIC LABORATORY—Same as M. E. 60. Mr. PARR, assisted by Mr. THURSTON. One afternoon. Fourth year Civil Engineering. Parallel courses: Technical Thermodynamics, C. E. 75 or 76, or 77 or 78.

64—AIR MACHINERY—Structures, Adaptability and Economy of Fans, Air, Gas and Vapor Compressors, Blowing Engines, Jet Blast Apparatus and Important Applications. Convection movement of air; flow of air through orifices, ducts, pipes. Hygrometric conditions of air with temperature and pressure and condensation of moisture in compressed air. Air compressors, types and construction; work of compression, M. E. P. for single and multi stage, cylinder ratios, effects of intercooling. Volumetric efficiency of compressors, real and apparent. Discharge pipe pressure pulsations, air receivers, intercooling receivers. Air end valves, poppet, slide, Corliss and ring valves, suction and delivery, differences in type and diameter and lift. Steam end valve gears and cylinder arrangement. Constant and variable speed compressor valve gear characteristics, pressure and speed controllers and governors. Analysis of complete compressor economy tests. Dry vacuum air pumps. Blowing engines, special forms and sizes of air end valves introduced by cylinders of large diameters for low pressure air. Ammonia and carbonic acid compressors; peculiarities and methods of handling liquid in the vapor; forms and characteristics. Multi-stage centrifugal fans and service. Analysis of efficiency tests for fans and blowers. Positive blowers. Steam jet blowers and exhausters, thermal efficiency. Application of principles to ventilation and heating, blast furnace practice, compressed air and compressed gas power transmission systems, air lift pumps and air brakes. Professor LUCKE and Mr. O'NEIL. Two hours per week. Third year Mechanical Engineering. Prerequisite courses: Mechanics 106; M. E. 17, 94S.

66—ELEVATORS AND CONVEYORS—Mechanical Handling of Solid Materials by Standard Elevating and Conveying Machinery, Characteristics, Speed, Tonnage and H.P. per Ton, Computations and Adaptability to Special Service. Hand handling of materials, limits, cost and conditions warranting use of machinery. Continuous conveyors, screw, bucket, scrapers, pusher, belt and pneumatic types. Intermittent conveyors; telephers, rope and cable ways, cable cars. Loaders, unloaders, storage facilities. Skips, grab buckets, tips and tipples. Short and long hoists, friction drum hoists and direct connected. Pneumatic and hydraulic elevators for freight. Fixed and travelling cranes. Passenger elevators, rope and plunger types. Safety devices. Automatic weighers of materials; coal and ore storage systems. Excavating machines and dredges. Coal and ore handling machinery. Railroad terminal and steamship loaders and unloaders. Coke oven chargers and dischargers. Grain handling. Special adaptation to material, sand, plaster, glass, cement, broken rock, coal, coke, packages, barrels, corrosive, erosive,

sticky packing and hot materials. Professor LUCKE and Mr. DODGE. One hour. Third year Mechanical Engineering. Prerequisite courses: M. E. 96S, 59, 11-12.

68—MANUFACTURING PLANT DESIGN—Methods of Procedure for the Design of a Plant for the Manufacture of an Assigned Product at a Given Rate. Determination of kind and quantity of materials needed, processes by which they may be most economically worked, selection of machinery for each process, determination of the number of each kind of machine required, power necessary to drive. Layout of shops for most direct production. Selection of facilities for handling, storing and shipping on the basis of economy effected. Grouping of pattern and machine shops, foundry, forge and general office; estimate of costs of equipment and installation. Layout of heating, ventilating and lighting systems, power transmission systems and facilities for reduction of fire hazard. Layout of system of management and cost determining system. Professor RAUTENSTRAUCH. Two hours and one afternoon. Fourth year Mechanical Engineering. Prerequisite courses are M. E. 19; E. E. 103; and must be paralleled by M. E. 52.

70—PUMPING MACHINERY—The Mechanics of Moving Liquids and Standard Machinery for Pumping. Water elevators, conditions for high efficiency and limits of use. Displacement, piston and plunger pumps; forms and functions of water pistons and plungers, pump bucket forms and limits of use, volumetric efficiency of water ends. Valves for water end, mechanical, flap, poppet, ball, annular, flat, double beat type and relation, adaptability to fluid, speed and temperature; forms of valve seats, conditions for perfect flow, piston speed and water inertia. Air chambers. Suction limitations of altitude, water temperature and absorbed gases and acceleration. Peculiarities of high pressure work, accumulators. Flywheel pumps, steam end characteristics, relation between steam and water diameters and displacements. Direct acting pumps, valve motion in single types, full and partial steam throw valves for simple, compound and triple use of steam. Duplex direct acting pumps, structural and operating characteristics. Economy of direct acting simple and multiple expansion pumps. Centrifugal and turbine pumps, forms and operative characteristics. High duty pumping engines, conditions for maximum duty referred to steam and coal; pumping engine tests, methods of conducting and analysis of results obtained. Typical pumping engine installations. Pulsometer pumps. Jet apparatus, injectors, ejectors and eductors, construction and duty as pumps. Mr. THURSTON. Water relief valves, pressure and float pump governors. Third year Mechanical, Civil and Chemical Engineering. Prerequisite courses: M. E. 17 and for Mechanical Engineering 96S.

72—GAS POWER MACHINERY—Short course adapted from M. E. 22. Professor LUCKE. 2 hours and 1 afternoon. Fourth year Electrical

and Metallurgical Engineering. Prerequisite course: M. E. 13-14, 76-77, 17-18.

74--Gas Power Machinery—Same as 72 except the time. Professor Lucke. Two hours. Fourth year Mining Engineering. Prerequisite courses: M. E. 13-14, 76, 17-18.

76-77—Experimental Engineering—Short course adapted from M. E. 31, 32, 33. Mr. Parr, assisted by Mr. Thurston. 76—Third year Metallurgical, third year Civil, fourth year Chemical, third year Mining and third year Electrical Engineering. 77—Fourth year Chemical and fourth year Electrical Engineering.

78—Kinematics—Short course adapted from M. E. 36. Professor Rautenstrauch. One afternoon. Third year Civil Engineering.

81-82—Heating and Ventilation—Principles of Heat Generation and Air Movement Applied to Warming and Ventilation of Buildings. Quantities of air needed for proper ventilation, amount of heat necessary to maintain temperatures against conduction, radiation and air change losses. Heating surface and coefficients of heat transfer, grate surface, pipe and duct sizes for high and low pressure steam heating, direct and indirect, hot water and hot air systems. Air tempering, cleaning, drying, humidifying. Pipe and duct layouts. Fan computations. Exhaust steam systems, vacuum circulation. Reducing valves, air valves, water expansion tanks, thermostats, thermostatic regulation systems and important details. Efficiencies of various systems and analysis of existing installations. Professor Lucke. Fourth year Sanitary Engineering, two hours per week. Prerequisite courses: M. E. 11-12, 13-14.

94S—Manufacturing Plant Summer Work—Practical Work and Directed Study in the Shops and Drafting Rooms of Representative Manufacturing Establishments with Report. Each student is provided with a printed copy of the things to be studied and reported on in detail, of which the following is a general summary:

Machine Shop. Functional operation, characteristics and powering of machine tools, capacities, layout of shop, size of shafting, belting and motors for independent and group drive. Range of cutting speeds, feeds, depth of cut. Shape and size of tools used. Report on specific observations on time of setting work, time of forming and finishing, number of pieces turned out per hour. Facilities for handling work at the machine. Facilities for producing pieces in quantity. Hand processes for finishing and tools used.

Pattern Shop. Materials of which patterns are made and methods of treating. Machine tools used in the pattern shop arrangement, capacities, adaptability, handling and storing of material and finished product.

Foundry and Forge. Description of hand and machine tools and appliances used in the foundry and forge. Compositing and treatment

of foundry sands. Methods of molding. Time involved. Methods of powering, venting and chilling, cooling and finishing, handling the cupola. Composition of the charges and mixtures, temperatures, pressures, time required to charge, to melt, to pour, cool and clean. Appliances in the forge shop. Operation of power hammers, bull-dozers, shears, heating and annealing furnaces and hand processes of forging. Time involved in production.

Drafting Room. Standards and conventions used. Filing and marking of drawings and recording of patterns. Bills of material—parts to be made—standard parts in stock.

General Management and Organization. Methods of recording time of workmen and their time distribution over on different jobs. Paying of men, methods, rates, forms and records used. Drawing of materials used from storeroom and charging to orders. Professor RAUTENSTRAUCH. Prerequisite course is second year shop work.

96S—POWER PLANT SUMMER WORK—Report based on not less than six weeks' practical work in an Operating Power Plant, including the Output, Loan Conditions, Labor and Material for Operation and Maintenance, Operating Cost per Unit and the Essential Dimensional Relations between the Various Units and Auxiliaries Producing this Result. This work is done entirely by the student in the field, his only assistance being the blank report form which is put in his hands after a brief lecture on leaving the University for the vacation. Professor LUCKE. Third year Mechanical Engineering. Prerequisite courses: M. E. 31-32.

Graduate Courses

201-202—RESEARCH—Special problems and original investigations in advanced mechanical engineering with conferences, laboratory work, and design as required.

Prereq. All courses offered in the department of Mechanical Engineering. Professors LUCKE and RAUTENSTRAUCH.

203-204—MECHANICS OF THE STEAM TURBINE—Advanced course based on M. E. 53, using Stodola, *The Stean Turbine* as a text, consisting principally of problem solution. Professor LUCKE.

205-206—VIBRATION IN MACHINES—Forces due to rotation of masses irregularly distributed in one plane; balancing of rotating systems by one or more new masses; rotation in several planes rotating couples; inertia effects of reciprocating masses; systems with both rotating and reciprocating and irregular moving masses; vibration of supports and framing; vibration of building; synchronism of period of building with period of machine. Professor LUCKE.

207-208—ADVANCED MACHINE DESIGN—Design of special machinery for specific processes, automatic machinery for rapid production of parts, and machinery for improving existing processes of manufacture. Professor RAUTENSTRAUCH.

SCHOOL OF CHEMISTRY

List of Officers

Charles F. Chandler, M.D., Ph.D., LL.D., Sc.D. . .*Mitchill Professor of Chemistry*
Charles E. Pellew, E.M. . . . . *Adjunct Professor of Chemistry*
Marston Taylor Bogert, A.B., Ph.B., *Professor of Organic Chemistry*
J. Livingston Rutgers Morgan, Ph.D. . . . . *Professor of Physical Chemistry*
James S. C. Wells, Ph.D. . . *Adjunct Professor of Analytical Chemistry (Qualitative)*
Henry C. Sherman, Ph.D. . . . . *Professor of Organic Analysis*
Samuel A. Tucker, Ph.B. . . . *Adjunct Professor of Electro-Chemistry*
Victor J. Chambers, Ph.D. . . . . *Instructor in Organic Chemistry*
Everett J. Hall . . . . *Instructor in Assaying*
Floyd J. Metzger, Ph.D. . . . . *Instructor in Analytical Chemistry*
Cavalier Hargrave Joüet, Ph.D. . . . . . *Tutor in Analytical Chemistry*
Arthur C. Neish, Ph.D. . . . . *Tutor in Chemistry*
Charles H. Ellard, A.M., *Tutor in Analytical Chemistry (Qualitative)*
Hal T. Beans, Ph.D. . . . . . *Tutor in Analytical Chemistry (Qualitative)*
Otto Kress, A.M. . . . . *Tutor in Chemistry*
William C. Uhlig, Ph.D. . . . . *Assistant in Analytical Chemistry (Qualitative)*
Eric Higgins, B.Sc. . . . . *Assistant in Physical Chemistry*
R. Calberla . . . . *Assistant in Electro-Chemistry*
Alfred Hoffman, Ph.D. . . . . *Assistant in Organic Chemistry*
—————— . . . . *Assistant in Analytical Chemistry*
—————— . . . . *Assistant in Analytical Chemistry*
—————— . . . . *Assistant in Analytical Chemistry*

For tabular statement of program of studies see pages 21 and 32.

General Statement

The regular four-year courses of instruction herein shown are designed for the education of professional chemists who intend to devote their lives to the practice of this profession, either as teachers in colleges and scientific schools, or as chemists or managers in manufacturing and other industrial enterprises.

There are two courses offered, leading to the degrees of Chemist and Chemical Engineer respectively.

Equipment

In Havemeyer Hall the Chemical Department is provided with ample space for its museum, lecture-rooms, and laboratories, and every convenience has been provided for both the instructors and students working in the general or special courses.

There are five chemical lecture-rooms, all fully supplied with apparatus and instruments, the desks being equipped with pneumatic troughs, gas, pressure, exhaust, and electricity. The large chemical lecture-room on the ground floor contains 315 seats.

The Museum of General Inorganic and Organic Chemistry and of the Chemical Arts, a large room occupying the whole left wing of the ground floor, contains the elements and all their more important compounds, inorganic and organic; materials and products illustrating the chemical arts, and numerous models, pictures, and diagrams.

The Qualitative Laboratory has 112 desks, each divided into two sections, and each thoroughly equipped.

The Quantitative Laboratory has eighty-eight desks. Attached to the main laboratory is a large, well-equipped balance-room, containing accurate balances, and special rooms, provided with apparatus for gas, water, food, and electrolytic analysis.

The Assay Laboratory is provided with crucible and muffle furnaces, both gas and coal, for the fire assay of ores; also with crushing, pulverizing, and sampling machinery, balance-room, storeroom, and thirty-six well-equipped working desks. It also contains all the apparatus necessary for the wet assay of silver bullion and for laboratory tests of ores.

The Organic Laboratory has forty large desks, provided with gas, water, exhaust, and electricity, and has special rooms for balances, pressure ovens, glass-blowing, and combustions.

The Laboratory of Industrial Chemistry, for the instruction of students in practical operations and the solution of problems in sanitary chemistry and hygiene, is equipped for the manufacture of pure chemicals from their raw materials on an industrial scale, with fine batteries of steam evaporators, and with steam stills, centrifugals, filter presses, crushers, and the like. It includes a dyeing laboratory with a large stock of dye-stuffs, and with the regular equipment for the practical testing of dyes, including a calico-printing machine. Connected with it is a photometer-room, containing a new and complete outfit for the practical testing of illuminants.

It also includes a laboratory for chemical microscopy, newly equipped with microscopes, polarized light apparatus, camera lucidas, etc., for the practical use of the microscope in chemical operations.

A new Laboratory for Practical Electrochemistry has been provided. The equipment consists of special motor-dynamos, one of which fur-

nishes direct current at low voltages to the students' desks for general electrolytic work; the other provides heavy alternating current to the electric furnace room; this room is furnished with all appliances for electric furnace work. The students' desks are fitted with special switchboards and measuring instruments, and the laboratory has been arranged for carrying on research work in all branches of electro-chemistry.

The Laboratory of Physical Chemistry is well equipped with the most recent apparatus adapted to a wide range of experimental work in the branches of heat, light, and electricity as applied to chemical problems.

The Chemical Library in Havemeyer Hall is supplied with an extensive collection of chemical books and journals, and is open from 9.00 A.M. to 5.00 P.M., and during the session of the University from 8.00 to 11.00 P.M.

Courses in Inorganic Chemistry

1 or 2—GENERAL CHEMISTRY—Elementary, designed to serve as an equivalent to the entrance examination in chemistry.

To include the chief physical and chemical characteristics, the preparation and the recognition of the following elements, together with their principal compounds: oxygen, hydrogen, carbon, nitrogen, chlorine, bromine, iodine, fluorine, sulphur, phosphorus, silicon, potassium, sodium, calcium, magnesium, zinc, copper, mercury, silver, aluminum, lead, tin, iron, manganese, chromium, and more detailed study of water, hydrochloric acid, carbon-monoxide, carbon-dioxide, oxides of nitrogen, nitric acid, ammonia, sulphur-dioxide, sulphuric acid, hydrogen sulphide, sodium hydroxide, ammonium hydroxide.

Special attention will be given to the atmosphere (constitution and relation to animal and vegetable life), flames, acids, bases, salts, oxidation and reduction, crystallization, combining proportions by weight and volume, calculations founded on these and Boyle's and Charles' laws, symbols and nomenclature, atomic theory, atomic weights, valency (in a very elementary way), nascent state, natural grouping of the elements, solution (solvents and solubility of gases and solids and liquids, saturation), strength of acids and bases, conservation and dissipation of energy, chemical energy, electrolysis, etc. 3 lectures and 2 afternoons laboratory practice, one-half year. Text-books: Remsen's *Chemistry, Briefer Course*, Elements of Chemistry by Hessler and Smith, Dr. NEISH.

3-4—GENERAL INORGANIC CHEMISTRY—Introduction. Laws of chemical combination, history, occurrence, preparation, and properties of the elements and their principal compounds. Text-book: Newth's *Inor-*

ganic Chemistry. 3 lectures and 1 recitation. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Course 1 or 2 or Entrance Examination in Chemistry.

7-8—INORGANIC CHEMISTRY—2 hours lectures or conferences throughout the year and 5 afternoons laboratory during the second half-year. Professor CHANDLER.

Designed for fourth-year students in the course of chemistry selecting a thesis in inorganic chemistry.

101-102—ADVANCED INORGANIC CHEMISTRY—Including the origin and development of the periodic law, and the history and properties of the rare elements. 2 lectures. Professor PELLEW.

Pre-requisite: Courses 3-4 and 61-62.

Summer Courses

For details, see the Announcement of the Summer Session.

S1 (S6)—GENERAL CHEMISTRY—5 hours lectures, 12 hours laboratory work, and 2 hours recitations. Mr. WILLIAMS and Mr. WHITMAN.

Physical Chemistry

21-22—ELEMENTARY PHYSICAL CHEMISTRY—3 hours a week in lectures and recitations, second half-year, and laboratory work 15 afternoons each half-year (equivalent to 1 afternoon throughout the year). Text-books: Portions of Morgan's *Physical Chemistry for Electrical Engineers* and Ostwald's *Physico-Chemical Measurements.* Professor MORGAN and Assistant.

Pre-requisite: Course 3-4 and Physics 3-4.

121-122—PHYSICAL CHEMISTRY—A course treating of the states of aggregation, solution, and ions in analytical chemistry, thermo-chemistry, chemical mechanics, and electro-chemistry. 3 hours lectures and recitations during the entire year, and 15 afternoons, equivalent to 1 afternoon a week, laboratory during the first half-year. Text-books: Morgan's *Elements of Physical Chemistry,* and Ostwald's *Physico-chemical Measurements.* Professor MORGAN and Assistant.

Pre-requisite: Course 3-4 and 61-62, Physics 3-4 and Mathematics 5-6.

37—THEORETICAL ELECTRO-CHEMISTRY—2 hours lectures and recitations. Text-book: Portions of *Morgan's Physical Chemistry for Electrical Engineers.* Professor MORGAN.

Pre-requisite: Course 3-4 and 65, Physics 3-4, and Mathematics 5-6.

23-24—PHYSICAL CHEMISTRY—2 hours in lectures or conferences throughout the year, and 5 afternoons laboratory during the second half-year. Professor MORGAN.

Designed for fourth-year students in the course of chemistry, selecting a thesis in physical chemistry.

221-222—ADVANCED PHYSICAL CHEMISTRY, LABORATORY COURSE—2 conferences and at least 16 hours in the laboratory throughout the year. Professor MORGAN.

Designed as a major course for candidates for the degree of A.M. Pre-requisite or parallel: Courses 121-122, 163-164.

223-224—ADVANCED PHYSICAL CHEMISTRY, RESEARCH—Original investigation. Professor MORGAN.

Designed as a major course for candidates for the degree of Ph.D. Pre-requisite or parallel: Courses 121-122, 163-164.

Summer Courses

For details see the Announcement of the Summer Session.

S37—ELEMENTARY PHYSICAL CHEMISTRY—5 hours. Prof. MORGAN.

RESEARCH—The laboratory is open to properly qualified students for research under the direction of Professor MORGAN.

Organic Chemistry

147-148—ORGANIC CHEMISTRY, ELEMENTARY LECTURE COURSE—An introductory course, which can be taken with advantage by college students and by those expecting to enter the medical course. Instruction given on such important classes of compounds as the hydrocarbons, alcohols, ethers, organic acids, fats, waxes, soaps, cyanides, sugars, carbohydrates, alkaloids, coloring matters, drugs, perfumes, and the like. The lectures will be liberally illustrated by material from the Chemical Museum and by experimental demonstration. Text-book: Remsen's *Organic Chemistry*. 2 hours. Dr. CHAMBERS.

Pre-requisite: Course 3-4. It is urged that, if possible, laboratory work, Course 43-44, be taken with this elementary lecture course.

43-44—ORGANIC CHEMISTRY, ELEMENTARY LABORATORY COURSE—A study of the typical methods for preparation and the typical reactions of the important classes of organic compounds. The laboratory work may be varied depending on the future needs of the student. Text-book: Gattermann's *Practical Methods of Organic Chemistry*. 8 hours. Dr. CHAMBERS.

Pre-requisite or parallel: Courses 3-4, and 147-148.

141-142—ORGANIC CHEMISTRY, GENERAL COURSE—A more comprehensive treatment of the subject, including a discussion of all the important classes of organic compounds. In the laboratory a large number of typical organic substances are prepared synthetically, and instruction is given in the methods of qualitative and ultimate organic analysis. In addition to this, students taking the course as a partial major for A.M. are required to submit an essay upon some special

line of practical work assigned by the instructor. Text-books: Richter's *Organic Chemistry,* Gattermann's *Practical Methods of Organic Chemistry,* Noyes and Mulliken's *Class Reactions and Identification of Organic Substances.* 4 lectures and 1 recitation a week for one year, and 4 afternoons laboratory the first half-year. Professor BOGERT and Dr. CHAMBERS.

Pre-requisite: Courses 3-4, 21-22, 161-162, and Physics 3-4.

143-144—ORGANIC CHEMISTRY, CONFERENCES—Presentation and discussion of recent important investigations in the field of organic chemistry. 2 hours. Professor BOGERT.

Required of all candidates for A.M. or Ph.D., taking major courses in organic chemistry and, together with 5 afternoons laboratory practice the second half-year, of all fourth-year students in the school of chemistry selecting a thesis in organic chemistry. Pre-requisite or parallel: Course 141-142.

241-242—ADVANCED ORGANIC CHEMISTRY, LABORATORY COURSE—An extended practical study of a given group of compounds, or a minor original investigation. Personal instruction, conferences, and laboratory work of not less than 12 hours a week throughout the year. Professor BOGERT.

Pre-requisite: Course 141-142.

243-244—ADVANCED ORGANIC CHEMISTRY, RESEARCH—Original investigation and research. Conferences, private study, and laboratory work. Professor BOGERT.

Pre-requisite or parallel: Courses 101-102, 141-142, 163-164.

Summer Courses

For details see the Announcement of the Summer Session.

s147-148 (s20)—ORGANIC CHEMISTRY—10 hours. Dr. CHAMBERS.

s42—ORGANIC CHEMISTRY—5 hours lecture and 35 hours laboratory. Dr. CHAMBERS.

s43-44 (s30)—ORGANIC CHEMISTRY, LABORATORY COURSE. Dr. CHAMBERS.

sF—CHEMISTRY OF NUTRITION.

RESEARCH—The laboratory is open to properly qualified students for research under the direction of Dr. CHAMBERS.

Analytical Chemistry

61 or 62—QUALITATIVE ANALYSIS—Lectures, conferences, and laboratory practice. Text-book: Wells' *Inorganic Qualitative Chemical Analysis,* and for reference, Treadwell's *Qualitative Analysis.* 4 lectures or conferences a week and 5 afternoons laboratory practice. Professor WELLS, Mr. ELLARD, Dr. BEANS and Dr. UHLIG.

Pre-requisite: Course 1 or 2 or its equivalent.

65—QUANTITATIVE ANALYSIS, INORGANIC, SHORT COURSE—Text-books: Miller's *Notes on Quantitative Analysis* and Miller's *Calculations of Analytical Chemistry,* 2 hours and 3 afternoons. Dr. METZGER and Dr. JOÜET.

The analyses included in this course are: Magnesium sulphate, potassium alum, coal, iron ore, copper, zinc, alkalimetry, acidimetry, and flue gas.

Pre-requisite: Courses 3-4 and 61-62.

66—QUANTITATIVE ANALYSIS, INORGANIC—Text-books: Miller's *Notes on Quantitative Analysis* and Miller's *Calculations of Analytical Chemistry.* 3 hours and 6 afternoons. Dr. METZGER, Dr. JOÜET and assistant.

The analyses included in this course are: Magnesium sulphate, potassium alum, iron-ammonium alum, coal, iron ore, pig iron, spiegel, zinc ore, limestone, slag, copper, lead, arsenic, antimony ores, and flue gas.

Pre-requisite: Courses 3-4 and 61-62.

161-162—QUANTITATIVE ANALYSIS, INORGANIC—Text-book: Talbot's *Quantitative Analysis.* 1 hour and 8 hours laboratory. Dr. METZGER and assistant.

Pre-requisite: Courses 3-4 and 61-62.

163-164—QUANTITATIVE ANALYSIS—The classroom work includes not only the methods applied in the laboratory, but discussions of quantitative separations from a theoretical standpoint, and chemical calculations. Text-books: Treadwell's *Quantitative Analysis;* and Miller's *Calculations of Analytical Chemistry.* 4 hours and 4 afternoons. Dr. METZGER and Dr. JOÜET.

The analyses included in this course are: Magnesium sulphate, sodium or other chloride, potassium alum, iron ammonium alum, coal, iron ore, pig iron, spiegel, limestone, slag, feldspar, ores of zinc, copper, nickel, lead, chromium, arsenic, antimony, alloys, rocks, gas analysis, etc.

Pre-requisite: Courses 3-4 and 61-62.

167-168—ADVANCED INORGANIC ANALYSIS—2 hours. Laboratory practice 5 afternoons during the second half-year for students in the course of Chemistry, who elect thesis work in inorganic analytical chemistry. Dr. METZGER.

In the first half-year, systematic volumetric analysis and technical analytical methods connected with iron, steel, copper, lead and zinc metallurgy. In the second half-year, rock analysis and the analytical chemistry of the rare elements.

Pre-requisite or parallel: Chemistry 101-102, 121-122, 163-164.

261-262—QUANTITATIVE ANALYSIS—Special methods, gravimetric, volumetric, and electrolytic. Conferences and laboratory work at least 16 hours a week. Dr. METZGER.

Pre-requisite: Courses 3-4, 61-62, 161-162.

263-264—Research—Conferences and laboratory work, 20 hours a week.

Original investigation in inorganic analysis or inorganic chemistry. Dr. Metzger.

Pre-requisite or parallel: Course 167-168.

171—Organic and Sanitary Analysis—The lectures include, in addition to the methods used in the laboratory, the interpretation of results in food and water analysis and discussions of the analytical chemistry of alcohols, carbohydrates, fats and oils. Text-books: Sherman's *Methods of Organic Analysis* and Mason's *Examination of Water;* for reference, Richards and Woodman's *Air, Water and Food.* 4 hours and laboratory work 5 afternoons for chemists, 3 afternoons for chemical engineers, 3 to 5 afternoons for graduate students. Professor Sherman and assistant.

The analyses included in this course are: Acidimetry and alkalimetry, alcohol, glycerol, formaldehyde, sugars, cream of tartar, milk, butter, fatty and lubricating oils, soap, paint, asphalt, fertilizers, and the sanitary analysis of water.

Pre-requisite: Courses 3-4, 61-62, 161-162 and 41-42.

173-174—Advanced Organic Analysis—2 hours throughout the year and laboratory work during the second half-year, 5 afternoons for fourth-year students in the Chemistry course who elect thesis work in organic analytical chemistry or food chemistry. Professor Sherman.

The analytical chemistry of proteids and their derivatives, alkaloids, tannins and fibres; plant analysis; advanced methods in food analysis; measurement of the activity of enzymes and the digestibility and nutritive value of food; systematic review of organic analysis.

Pre-requisite or parallel: Course 171 (or equivalent work in 271-272).

176—Chemistry of Food and Nutrition—The chemistry and functions of the foodstuffs; the composition and nutritive values of food materials; the amounts of food required in nutrition; methods of determining the nutritive values of special foods and the effects of adulteration; food legislation and inspection; standards of purity for food products; normal and abnormal variations in composition. 3 hours. Professor Sherman.

271-272—Special Methods of Organic Analysis and Food Investigation—Conferences and laboratory work, 12 hours a week. Professor Sherman.

Pre-requisite: Courses 3-4, 61-62.

273-274—Research—Conferences and laboratory work 20 hours a week.

Original investigation in organic analysis or food chemistry. Professor Sherman.

Designed as a major course for candidates for the degree of Ph.D.
Pre-requisite or parallel: Course 173-174.

69 or 170—Assaying—Ores and metallurgical products. Text-book: Fulton's *Manual of Assaying* 2 lectures or recitations a week, and laboratory practice, during the first half-year for mining engineers and metallurgists; during the second half-year for chemists. Mr. Hall.

The assays included in this course are: Preliminary (reagents, etc.); lead and tin ores; gold and silver ores, pure and impure, including galena, stibnite, arsenopyrite, blende, pyrite, tellurides, etc.; mattes and tailings; corrected assays and extraction tests; gold, silver, and lead bullions.

Laboratory work for mining engineers and metallurgists, 3 afternoons during the first half-year; for chemists, 3 afternoons during the second half-year. Pre-requisite: Course 3-4, 61-62, and Mineralogy 1-2 or 7-8.

160—Special Methods of Assaying Ores, Alloys, and Furnace Products—Comparison of methods and determination of losses. Conferences and laboratory work at least 8 hours a week for one half-year. Mr. Hall.

Pre-requisite: Courses 3-4, 61-62, 69, and Mineralogy 1-2 or 7-8.

Summer Courses

For details, see the Announcement of the Summer Session.

s61-62—Qualitative Analysis—7 hours lectures and conferences, and 30 hours laboratory work a week. Dr. Beans.

s161-162—Quantitative Analysis—5 hours lectures and 30 hours laboratory work a week (accepted for Course 65). Dr. Joüet.

sF—Chemistry of Nutrition—5 hours lectures. Professor Sherman.

s171a—Organic and Sanitary Analysis—Conferences and laboratory work 12 to 30 hours a week. Professor Sherman and assistant.

Research—The laboratory is open to properly qualified students for research. In analytical chemistry or the chemistry of foods under the direction of Professor Sherman.

Industrial Chemistry

81-82—Industrial Chemistry, General Course—The subjects discussed are: (1) Air: nature, sources of contamination, sewer gas, plumbing, draining, disinfection, ventilation. (2) Water: composition of natural waters, pollution, disposal of sewage and house refuse. (3) Artificial illumination: candles, oils and lamps, petroleum, gas and its products, electric light. (4) Limes, mortars, and cements. (5) Building-stones: decay and preservation. (6) Timber and its preservation: pigments, paints, essential oils, varnishes, preserving processes. (7) Explosives: gunpowder, gun-cotton, nitro-glycerine. (8) Glass and

ceramics. (9) Electro-metallurgy. (10) Photography. Text-books: Park's *Hygiene* and Wagner's *Chemical Technology.* 3 hours lectures. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Course 3-4.

83-84—INDUSTRIAL CHEMISTRY, SPECIAL COURSE—The subjects discussed are: (1) Chemical manufactures: acids, alkalies, and salts. (*a*) Sulphur, sulphurous acid, hyposulphites, sulphuric acid, bisulphide of carbon. (*b*) Common salt, soda ash, hydrochloric acid, chlorine, binoxide of manganese, bleaching powder, chlorates, chlorimetry. (*c*) Carbonate of potash, caustic potash. (*d*) Nitric acid and nitrates. (*e*) Iodine, bromine. (*f*) Sodium, aluminum, magnesium. (*g*) Phosphorus, matches. (*h*) Ammonia salts. (*i*) Cyanides. (*j*) Alum, copperas, blue vitriol, salts of magnesia, baryta, strontia. (*k*) Borates, stannates, tungstates, chromates. (*l*) Salts of mercury and silver. (*m*) Oils, fats, soaps, and glycerine. Text-books: Wagner's *Chemical Technology;* Lunge's *Manufacture of Sulphuric Acid and Soda.* 3 lectures. Given alternate years. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Courses 3-4, 81-82.

85-86—INDUSTRIAL CHEMISTRY, SPECIAL COURSE (*continued*) (2) Food and drink: milk, cereals, starch, bread, meat, tea, coffee, sugar, fermentation, wine, beer, spirits, vinegar, preservation of food. (3) Clothing: textile fabrics, bleaching, dyeing, calico printing; paper, tanning, glue, india-rubber, gutta-percha. (4) Fertilizers: guano, superphosphates, poudrettes. Text-books: Wagner's *Chemical Technology;* Lunge's *Manufacture of Sulphuric Acid and Soda;* Schultz' and Julius' *Kuenstlichen Organischen Farbstoffe;* Schultz' *Chemie des Steinkohlentheers.* 3 hours lectures. Given alternate years. Professor CHANDLER and Mr. KRESS.

Pre-requisite: Courses 3-4, 81-82.

87 or 88—INDUSTRIAL CHEMISTRY, LABORATORY PRACTICE—Preparation of inorganic chemicals, including the preparation and purification of chemical reagents, pigments, and salts of the rare as well as of the common metals. 3 afternoons. Professor PELLEW.

Pre-requisite: Courses 3-4, 61-62.

89—INDUSTRIAL CHEMISTRY, LABORATORY PRACTICE—Special applications: Textile industry, vegetable and animal fibres, bleaching, dyeing, and calico printing. 1 afternoon a week. Professor PELLEW.

Pre-requisite: Course 3-4, 61-62, 147-148.

91-92—CHEMICAL MICROSCOPY—The use of the microscope for the identification of crystalline chemical compounds, fibres, starches, urinary sediments, micro-organisms, etc., with special application to the detection of poisons and food adulterants. 4 hours laboratory practice a week. Professor PELLEW.

95-96—INDUSTRIAL CHEMISTRY—2 hours throughout the year, and 5 afternoons in the laboratory during the second half-year. Professor PELLEW.

Designed for fourth-year students in the course of chemistry selecting a thesis in industrial chemistry.

97—CHEMICAL FACTORY APPARATUS AND MACHINERY—3 hours.

To cover the construction and use of pumps, tanks, filter presses, evaporating pans, grinding and other chemical machinery. (*To be given in* 1908-09.)

98—COST OF CHEMICAL OPERATIONS IN FACTORIES—3 hours.

To include: Methods of determining costs as affected by the price of fuel, of labor, of repairs, and by interest charges. Dependence of cost upon locality, price of transportation and size of plant. Average cost of such operations as evaporation, filtration, moving solutions, etc. (*To be given in* 1909.)

295-296—INDUSTRIAL CHEMISTRY, ADVANCED COURSE—Original research; the study and investigation of methods and processes in sanitary and industrial chemistry. Personal instruction and laboratory work for one year. Professor PELLEW.

Designed for candidates for the degrees of A.M. or Ph.D. Pre-requisite or parallel: Courses 101-102, 121-122, 141-142, 163-164.

Electro-Chemistry

93-94—ELECTRO-CHEMISTRY—2 hours in lectures or conferences throughout the year, and 5 afternoons in the laboratory during the second half-year. Professor TUCKER.

Designed for fourth-year students in the course of chemistry selecting a thesis in electro-chemistry.

181 or 182—PRACTICAL ELECTRO-CHEMISTRY—Electro-plating, influential factors in electrolysis, electrolysis with molten electrolytes, the use of diaphragms, electrolytic preparations, electric furnace practice. 5 afternoons. Professor TUCKER.

Pre-requisite: Courses 3-4, 61-62, 65.

183-184—INDUSTRIAL ELECTRO-CHEMISTRY—Theory and practice of electrolysis, electro-deposition, electric smelting and refining, primary and secondary batteries, production, preparation and purification of chemicals and metals. 1 hour and the equivalent of 14 afternoons laboratory work. Professor TUCKER.

Pre-requisite: 3-4, 65.

281-282—ELECTRO-CHEMICAL RESEARCH—Original investigation and research equivalent to 16 hours a week during one year. Professor TUCKER.

Pre-requisite: Course 181 or 182.
Designed as a major course for A.M. degree.

283-284—ADVANCED ELECTRO-CHEMICAL RESEARCH—Private study, original investigation and research for two years. Professor TUCKER.

Pre-requisite: Course 181 or 182.

Designed as a major course for Ph.D. degree.

80a—FACTORY INSPECTION AND SUMMER MEMOIR—Second Year.

Visiting and inspection of chemical works of special interest in and near New York City, such as gas works, petroleum refineries, sugar houses, dyeing and calico-printing establishments, paint and varnish factories, soap, candle and oleomargarine works, paper mills, and plants for the purification of water and sewage. Professor PELLEW.

Also a memoir descriptive of some chemical process, the subject to be assigned to each student.

Required of all second-year students in the course of chemistry. The visits to factories are made during the two weeks following the final examinations. The memoir must be wholly completed by December 1st.

80b—FACTORY INSPECTION AND SUMMER MEMOIR—Third Year.

Similar to 80a, excepting that the memoir covers description, working plans, and full estimate of cost of a chemical laboratory, according to outlines assigned to each student. Professor PELLEW.

Required of all third-year students in the course of chemistry.

N.B. A student failing to hand in his completed memoir by December will be obliged to pay a fee of $5.00, as for a special examination.

OTHER COURSES

Prescribed for the Degrees Offered Under the Faculty of Applied Science

COURSES IN ASTRONOMY

105—GEODESY—Brief history of geodetic operations and description of theodolites, base apparatus, and other instruments used in geodetic work, including their adjustment and use. Reference books: Crandall's *Geodesy and Least Squares, United States Coast Survey Reports,* Jordan's *Handbuch der Vermessungskunde,* and Wilson's *Topographic Surveying.* 3 hours. Professor MITCHELL.

106—GEODESY—The applications of practical astronomy to geodetic surveying, and training in methods of accurate computation. Textbook: Campbell's *Elements of Practical Astronomy,* 1 hour and 1 laboratory period. Professor MITCHELL.

107—GEODESY—Summer Course in Practical Geodesy: Given in the field, each student making his own observations and calculations. The outline of laboratory and summer works:

I.—1. Use of the Ephemeris. 2. Conversion of mean time into sidereal time and *vice versa,* and apparent time into mean time and *vice versa.* 3. Values of level divisions obtained by means of the "level trier." II.—Sextant. 1. Construction of the instrument. 2. Theory of the instrument. 3. Adjustments. (*a*) Angle measuring. (*b*) Time by altitudes of the Sun. (*c*) Latitude by altitudes of the Sun. (*d*) Latitude by circum-meridian altitudes of the Sun. III.—Transit instrument, clock and chronograph. 1. Construction. 2. Theory of instruments. 3. Adjustments. 4. Star lists and tables. 5. Observations and reductions for constants and time error of clock. IV.—Base measuring. 1. Construction of apparatus. 2. Adjustments. 3. Measurement of a base and reduction of observations. V.—Angle measuring by "directions." 1. Construction of instrument. 2. Adjustments. 3. Observations and reductions. 4. Triangulation. VI.—Determination of the true meridian, and the azimuth of a line. 1. Theory of methods. 2. Observations and reductions. VII.—Barometric hypsometry. 1. Constructions of instruments. 2. Adjustments. 3. Formulæ and tables. 4. Observations and reductions.

Practical work at Morris, Conn. Professors JACOBY and MITCHELL, with Assistants.

Pre-requisites for all courses: Mathematics of first two years.

COURSE IN BOTANY

7—GROWTH AND CHARACTER OF TIMBER—This work considers the growth of the tree and the character and arrangement of its tissues; the relation of water content in timber to its resistance to stress; the deterioration and preservation of lumber and its distribution and identification.

One hour and one afternoon each week during first term of second year for Civil Engineering students. Professor CURTIS and Mr. DARLING.

COURSES IN DRAFTING

1-2 (*a*)—Elements of mechanical drafting—Use of instruments; plane problems; freehand lettering; dimensioning;

(*b*)—Projections—Orthographic projection; intersections; developments; problems in descriptive geometry; isometric projection; cabinet projection;

(*c*)—Machine drafting—Conventional signs for materials of construction; sketching of machine details. Working drawings; tracings; blue printing;

(*d*)—Topography—Conventional signs; hill shading; mapping.

1 hour lecture and 14 hours drafting for one half-year. Professor MAYER, Mr. MILLER, Mr. HARRINGTON and Mr. WEINRICH.

3-4—Descriptive geometry—Problems on point, line, and plane; classification of surfaces; tangent planes to single curved surfaces and surfaces of revolution; intersections; developments; warped surfaces. 3 hours for one half-year. Professor MAYER, Mr. MILLER and Mr. HARRINGTON.

5-6 (*a*)—Graphics—Shades and shadows; perspective;

(*b*)—Stone cutting—Buttress; wing-wall; arches.

6 hours drafting for one half-year. Prof. MAYER and Mr. MILLER.

Pre-requisite: Drafting **1-2, 3-4**

7-8 (*a*)—Structural drafting—Standard rolled sections; conventional riveting signs; standard connections; methods of framing and detailing structural work; beams; columns; plate girder; roof trusses; bridge details;

(*b*)—Machine drafting—Working drawings; tracing and blue prints of machine details; boiler and engine-room layouts, etc.

6 hours drafting for one half-year. Professor MAYER, Mr. MILLER, and Mr. HARRINGTON.

Pre-requisite: Drafting **1-2, 3-4**

Equipment

The drafting rooms and offices, situated on the fourth floor of the Engineering building, are equipped with a standard form of drafting table, and have a seating capacity for 175 students.

The collections of the department contain a complete set of models illustrating problems in projections and descriptive geometry, as well as the usual charts, blue prints, and models for use in the lecture and drafting rooms. A special feature of the collection is a full set of Olivier models illustrating the warped surfaces and problems in intersections and tangencies.

COURSES IN GEOLOGY

4—Petrography—A short course in the microscopic study of rocks. 2 afternoons two months of the second half third year. Dr. Berkey

Pre-requisite: Mineralogy, 6

6—General Geology—First half-term physical geology, with practical work in the rock collections under the lithological part of the subject; second half-term, stratigraphical and historical geology, involving laboratory work with type fossils and collections illustrating the geology of the United States. Text-books: Kemp's *Hand-book of Rocks*; Scott's *Introduction to Geology*. 6 hours lectures, second term, second year. Professor Kemp, Dr. Berkey, and Professor Grabau

Pre-requisite: Mineralogy 1

16—Index Fossils—A study of the invertebrate fossils characteristic of the various geologic horizons of North America. 1 hour lectures, 8 hours laboratory, second term.

18—General Geology—A general discussion of dynamical, structural and historical geology, with practical work in the rock collections and assigned field work on Saturdays during the last six weeks. Special course during the second half-year for students in Civil Engineering only. Dr. Berkey.

19—Physiographic and Applied Geology—A study of topographic and structural features and their representation on maps; application of geologic principles to engineering enterprises; water supply; illustrative problems. Open to students having completed a course in general geology. 3 hours lectures and laboratory by appointment, first term. Dr. Berkey.

51—Principles of the formation of sedimentary deposits, involving a discussion of marine and continental sedimentation, the criteria by which various sediments can be recognized, methods of preservation of organic remains, and the principles of geographic and geologic distribution of organism. Principles of correlation. Two lectures per week. Professor Grabau. First term. Text book: *Grabau's Principles of Stratigraphy.*

52—A discussion of secondary structural features; principles of formation of folds, faults, etc. Vulcanism, metamorphism, secondary mineralization. Two lectures per week, second term. Professor Kemp and Dr. Berkey.

105-106—Economic Geology—First half-year, discussion of the general features and formation of ore bodies, followed by a description of the deposits of the ores of iron, copper, lead, zinc, silver, gold, and the lesser metals, with especial reference to North America; second half-

year, a description of the distribution and occurrences of coal, petroleum, natural gas, asphalt, building-stone, water supply, salines, and minor minerals. Text-book: Kemp's *Ore Deposits of the United States and Canada,* and lecture notes privately printed. 3 hours lectures and conferences, third year. Professor Kemp

Pre-requisite: Geology, 6

107-108—Invertebrate Palæontology—First part of the course deals with the principles of palæontology; methods of study of the ontogeny of hard parts of animals, and the laws of morphogenesis. This is followed by a consideration of the classes of invertebrates important from a palæontologist's point of view, emphasis being laid on the features which show genetic relationship. Special attention is given to groups whose evolution has been worked out. Text-book: Zittel-Eastman, *Text-book of Palæontology,* Vol. 1. 2 hours lecture and 4 hours or more laboratory. Professor Grabau and Mr. Kirk.

110—Geological Examinations and Surveys—A discussion of the methods of systematically recording and interpreting geological phenomena; and of the organization and scope of geological surveys on a larger scale. This is followed by a sketch of the history and results of state and national geological surveys in this and other countries; and of other sources of detailed information regarding local geology. 2 hours, second half fourth year. Professor Kemp

Pre-requisite: Geology 105-106

112—Field Geology—A summer course of a week or ten days near New York for students in the course of Mining Engineering. Graduate students in the department may join either one or both of these parties. Instruction is given in the field in observing, recording, and interpreting geological phenomena and in the preparation of maps and sections. A written report is required.

201-202—Petrology—A discussion of the origin, microscopic structure, and mineralogical composition of the crystalline rocks, and of metamorphism. 2 hours lectures and 4 hours laboratory, fourth year. Professor Kemp

Pre-requisite: Mineralogy 6

205-206—Comparative Geology of North America—A description and a study of the geological formations of America, their areal distribution and time relations, the various schemes of classification, the character of the rocks, the typical forms of life, and the upheavals and igneous intrusions of each period. Special emphasis is laid on palæogeographic development of North America. Text-books: *The Correlation Bulletins of the U. S. Geological Survey,* the *manuals* of Dana and Geikie, and the various state and national *survey reports.* 3 hours

lectures, and at least 4 hours laboratory and reading. Professor Kemp for the crystalline rocks, Professor Grabau for the sedimentary.

303-304—Journal Club and Seminar, conducted by the officers of the department weekly, as arranged by consultation.

COURSES IN MATHEMATICS

2—Higher Trigonometry—Includes the development of the trigonometric functions into series, Euler's exponential equations, De Moivre's Theorem and its application to the solution of binomial equations and spherical trigonometry with its applications. Professor Mitchell, Mr. Maxson and Mr. Siceloff. 2 hours, second half of first year.

Pre-requisite: Entrance Mathematics

3-4—Analytical Geometry (Candy)—3 hours, first year. Professor Mitchell, Dr. Ling, Mr. Maxson and Mr. Siceloff.

Pre-requisite: Entrance Mathematics

5—Differential and Integral Calculus (Osborne)—5 hours, first half of second year. Professors Van Amringe, Fiske, Maclay and Keyser.

Pre-requisites: Mathematics 2 and 3-4

COURSES IN MINERALOGY

6—Optical Mineralogy—Principles, apparatus, and distinguishing characters of minerals in thin sections. 2 afternoons laboratory work for two months of second half of third year. Professor Luquer and assistant

Pre-requisites: Mineralogy 1

1—Descriptive and Determinative Mineralogy—The elements of crystallography. The blowpipe analysis of ores and other substances. The study of the important minerals, the purpose being: 1st. Sight recognition of average specimens of all common or economically important species; 2d. Rapid determination of the less characteristic specimens by simple tests; 3d. Familiarity with economic characters. 6 hours lectures, 9 hours laboratory. Professor Moses, Professor Luquer and assistants.

Pre-requisites: Entrance requirements in Chemistry and Physics
Prescribed course for students in Mining

5—The Minerals of Building Stones—Study of common species, their properties, methods of determination, and their economic effect on building stones. 2 hours lectures and 1 afternoon laboratory during first half-year. Professor Luquer and assistant.

Prescribed for students in the course of Civil Engineering

6—Optical Mineralogy—Principles, apparatus, and distinguishing

characters of minerals in thin sections. Second half-year, first seven and a half weeks. Professor LUQUER and assistant.

Pre-requisite: Course 1 or its equivalent

In sections, 2 afternoons per week.

Prescribed for students in Mining and Metallurgy

Consists principally in the determination of minerals in rock sections by the aid of the polarizing microscope. It supplements courses 5 and 1 and is preliminary to geology 4 (petrography).

7—DESCRIPTIVE AND DETERMINATIVE MINERALOGY—Modification of Mineralogy 1. Lectures identical, laboratory work condensed. 6 hours lectures, 6 hours laboratory.

Prescribed course for students in Metallurgy

15-16—MINERALOGY—Sight recognition and determination of minerals important in the chemical industries. 3 hours laboratory. Professor MOSES and assistant.

Pre-requisites: Chemistry A and Physics A
Prescribed for students in Chemistry and Chemical Engineering

COURSES IN PHYSICAL EDUCATION

PHYSICAL EDUCATION. A1-A2—Two hours a week of elementary graded gymnastic exercises and lectures on Personal Hygiene. Dr. SKARSTROM.

In Sections.

PHYSICAL EDUCATION. B1-B2—Two hours a week of graded gymnastic exercises and lectures on Personal Hygiene. Professor MEYLAN and Mr. PRETTYMAN.

COURSES IN PHYSICS AND MATHEMATICAL PHYSICS

Physics 3-4—ELEMENTARY MECHANICS AND GENERAL PHYSICS—Professor HALLOCK, instructors, and assistants.

Physics 3, five hours a week during first term.

Physics 4, three hours a week during second term.

This course is required of all first year students in Engineering and consists of lectures and recitations. Physics 3 treats the subjects of Mechanics and Sound, three lectures and two recitations each week. Physics 4 treats the subjects of Heat, Light, Electricity and Magnetism, two lectures and one recitation each week.

Physics 43-44—INTERMEDIATE LABORATORY COURSE—Professor TUFTS, instructors and assistants. Three consecutive hours of laboratory work twice a week for one half year; given each half year.

Pre-requisite: Physics 3-4

This course consists of quantitative experiments, reports, and individual instruction in the laboratory, and is designed to familiarize the student with the applications of the fundamental principles of mechanics and physics, methods of computation and the determination of the probable error of results.

Physics 105—Electrical Measurements—Professor Parker—Two hours.

Pre-requisites: Physics **3-4**

Critical discussion of electrical measurements and computations.

Mathematical Physics 7—Thermodynamics—Dr. Pegram. Two hours.

Pre-requisites: Physics **3-4** or **9-10** and Mathematics **5**

Mathematical Physics 102—Analytical Mechanics—Professor Pfister. Five hours.

Pre-requisites: Physics **3-4** and Mathematics **5**

This course is intended primarily for students of engineering. Maurer's *Technical Mechanics* is used as a text. Recitations are supplemented by illustrations of typical problems affording actual applications of the principles and by the chapters on torsion and stress from Rankine's *Applied Mechanics.*

Mathematical Physics 105—Thermodynamics—Professor Wills. Two hours.

Pre-requisite: Mathematical Physics **102**

An idea of the nature of the course may be obtained from the following topical headings. The nature of heat; thermometry; calorimetry; heat and work diagrams; the First Law; applications to gasses, perfect and actual; the work of Carnot; the Second Law; the Kelvin absolute scale of temperature; the combination of the two laws; application to the problem of change of state; the properties of saturated and superheated steam; theory of the "plug experiment"; the flow of fluids from orifices.

Mathematical Physics 107-108—Theory of Electricity and Magnetism—Professor Wills. Two hours first half year, three hours second half year.

Pre-requisite: Mathematical Physics **102**

The fundamental principles of electricity and magnetism are developed and discussed with particular reference to the bearing which they have in relation to the science of electrical engineering. The course concludes with an introduction into the theory of alternating currents.

Mathematical Physics 109—Theory of Alternators and Transformers—Professor Pupin. Two hours.

Pre-requisite: Mathematical Physics **107-108**

Mathematical Physics 110—Theory of Variable Currents—Professor Pupin. Two hours.

Pre-requisites: Mathematical Physics **109**

This course treats particularly of the theory of polyphase and high frequency and high potential currents.

Mathematical Physics 205—ELECTRICITY AND MAGNETISM—Professor PUPIN. Two hours.

Fundamental phenomena; derivation of Maxwell's Equations; electrostatics; magnetostatics; stationary states; variable states; dynamical phenomena.

Mathematical Physics 206—THEORY OF ELECTRICAL CIRCUITS—Professor PUPIN. Two hours.

Briefly stated, this course covers advanced electro-mechanics, that is, the mathematical theory of generation and distribution of electrical power by variable electromotive forces. It deals with the theory of construction of alternating current generators, motors, and transformers, and with the theory of the construction of transmission lines for power distribution, telegraphy and telephony; also with wireless signalling.

Mathematical Physics 211-212—PARTIAL DIFFERENTIAL EQUATIONS OF PHYSICS—Professor MACLAURIN. Two hours.

Laplace's Equation; Poisson's Equation; Equation of Heat Conduction; Telegrapher's Equation; Fourier's Series; Spherical Harmonics; Bessel's Functions.

For other courses in physics and mathematical physics the student is referred to the Announcement of the Division of Mathematical and Physical Science.

COURSES IN SHOP WORK

Equipment

THE WORK-SHOPS are located in the Macy Manual Arts Building of Teachers College, 120th Street, and may be generally divided into two groups, each having a capacity of from twenty to twenty-four workers. The wood-working course is planned to lead up to pattern-making and foundry-work. The equipment includes benches for joinery and pattern-making with the necessary hand-tools, and speed lathes for wood-turning. The foundry division has facilities for bench and floor moulding and for limited work with sweeps. A carpenter shop with saw-benches, planers and tools for profile-sawing is available for working up stock and special appliances.

The second division includes the shops for metal-working. For blacksmith work and forging are twenty Buffalo forges with anvils, tools, and vises. A 30-pound Bradley power-hammer and a 400-pound Billings and Spencer drop-press are used to illustrate and enforce the application of the forge processes to manufacturing.

For machine-tool work a well-equipped shop contains engine-lathes, swinging from twelve to twenty inches, planers, shapers, drill-presses,

universal milling machine, universal grinding machines and the subsidiary appliances of the machine shop. A Jones and Lamson flat turret-lathe, and a Warner and Swasey screw machine are used to familiarize the student with modern methods of rapid and economical production, and he is expected to learn their use in manufacturing processes. The tool room is administered according to advanced standards, the attendance record is kept by a Willard & Frick time-keeper's recording clock, and a regular shop organization and atmosphere is aimed at.

1—Joinery and pattern making. Shopwork, demonstrations and shop visits. The construction of typical patterns and core boxes, solid, split and piece, involving the use of bench tools and turning lathe. Mechanical Engineering, Second year. 2 afternoons, first term. Mr. Weick.

2—Molding and foundry practice. Shopwork, demonstrations and shop visits. Bench molding with type patterns, swept work in green sand and loam and molding in dry sand. Mechanical Engineering. Second year. 1 afternoon, second term. Mr. Weick.

3—Forging. Shopwork, demonstrations and shop visits. Management of fire, shaping, drawing, upsetting, swaging, welding, tempering and die-forging. Work on drop and helve hammers. Mechanical Engineering. Second year. 2 afternoons, second term. Mr. Sleffel.

4—Machine work. Shopwork, demonstrations and shop visits. Practical work with the lathe, planer, drill, shaper, milling machine, grinder and turret lathe. Assembling, erection and rigger's work. Mechanical Engineering. Three weeks in June, second year, and 2 afternoons, first term, third year. Mr. Haight.

5—Machine work. As above. Electrical Engineering. Second year. 1 afternoon. Mr. Haight.

6—Forging and foundry practice. As above. Civil Engineering. Second year. 1 afternoon, first term. Mr. Sleffel.

7—Machine work. As above. Civil Engineering. Second year. 1 afternoon, second term. Mr. Haight.

8—Forging foundry practice and machine work. As above. Chemical Engineering. Second year. Three weeks in June. Mr. Sleffel and Mr. Haight.

GENERAL INFORMATION REGARDING COLUMBIA UNIVERSITY

Students under the Faculty of Applied Sciences may enjoy every advantage to be derived from the resources of the University. The University occupies thirty-five buildings, and its grounds cover thirty-five acres. The number of officers of instruction in 1907-8 was 609, and of resident students 5152.

University Library

The Library is open each week day (except Thanksgiving, Christmas, Good Friday, and Independence Day) from 8.30 A.M. until 11 P.M., October-June; and until 10 P.M., July-September. All students and graduates have free access to the Library and may draw books for home use.

The Library contains about 400,000 volumes, exclusive of unbound pamphlets and duplicates, and about 30,000 German dissertations. It is catalogued both by authors and by subjects. The catalogue is on cards accessible to readers.

Physical Exercise

The Gymnasium is open daily during the academic year, except on Sundays and legal holidays, from 9.30 A.M. to 7 P.M., Saturdays to 6 P.M. It is closed for the entire day only on Thanksgiving, Christmas, New Year's, and Good Friday. On all other holidays it is open from 2 to 6 P.M. At least one of the instructors is on the floor at all times when the Gymnasium is open.

Every student is entitled to a physical examination by the Medical Director. On the basis of this examination advice is given as to the kind and amount of exercise best adapted to his needs. For the Gymnasium fee see page 15.

The main exercising room is 35 feet high, semicircular in shape, and has an area of 16,000 square feet. It is well lighted and well ventilated. The running track is 11 feet wide, with ends raised, and measures 10 laps to the mile. On the same floor with the running track are the offices, rooms for fencing, boxing, and handball, two large dressing-rooms with 1,804 steel lockers, and 32 shower-baths. Below the exercising room is the swimming pool, semicircular in shape and 100 feet by 50. The depth is from 4 to 10 feet. Around the pool are the dressing-rooms and shower-, needle-, and tub-baths. On this floor also are rooms for the use of the various athletic teams.

Work in the gymnasium to the extent of two hours a week for two years is prescribed for students in Mining, Engineering and Chemistry. A physical examination is required for each student upon entrance and at the end of this prescribed work.

The work prescribed for these classes is arranged with a view to securing three definite ends: first, health; second, strength, control, efficiency, and endurance; third, erect carriage and correct position of the head, shoulders, and chest. Students are marked upon the basis of attendance, effort, and knowledge of the subjects taught, and a passing mark is necessary for a degree.

There are on South Field a practice field for baseball, lacrosse, and football, a running track, nine tennis courts, and eight outdoor handball courts.

Committee on Employment for Students

It is the design of the Employment Committee to give to students desiring to work their way through college the opportunity to earn enough for their partial or complete support, or, if possible, to extend assistance to them in other ways. Some of the openings available are: private tutoring, translating, addressing, copying of various sorts, teaching in the evening schools, stenography, and typewriting. During the year 1906-07 the student earnings reported to the Committee amounted to $111,161.28. Communications should be addressed to the Committee.

While much work is found for students each year, preference is naturally given, in case of a choice of applicants for a position, to those who have spent at least a portion of a year at Columbia, and thus have become personally known to members of this Committee or to other officers, and to those who, as strangers in New York, are not likely to hear of positions through other channels. No prospective student should come to Columbia expecting to depend entirely or even largely upon the assistance of the Committee, and every student should be prepared to meet at least the expenses of the first half-year—say two hundred and fifty dollars.

The chiefs of clinics in the Medical School give advice without charge to students on the lists of the Committee.

There are also Appointment Committees whose duty it is to recommend graduates for teaching or other positions in colleges and universities and to assist competent men to obtain such positions.

Medical Visitor

For the benefit of those members of the University who are without family physicians in New York City, the Trustees have designated a Medical Visitor, whose duties are to render medical assistance to such students as may desire it, either at their homes or elsewhere, for a

remuneration to be arranged between himself and individual patients. The medical visitor is Dr. D. S. D. Jessup, whose office hours are from 5 to 6 daily, at 301 West 108th Street (telephone, 8153 Riverside).

University Commons

The University Commons for the accommodation of the men living in the Residence Halls is conducted upon a system combining *table d'hôte* and *à la carte*. The Commons, which has accommodations for 450 men, is in University Hall and is open daily from 7.30 A.M. to 7 P.M. Under the same management is a large buffet lunch room.

Residence Halls

Hartley Hall, a memorial to the late Marcellus Hartley, and Livingston Hall, named in memory of Robert R. Livingston, of the class of 1765, University dormitories on South Field, with accommodations for 500 men, were opened in September, 1905. Each building is 10 stories in height exclusive of basement, and 137 feet long by 60 feet wide. They are lighted throughout by electricity and heated by steam, with telephone connection on each floor. There are four electric passenger elevators.

The two Halls contain 600 rooms, both single and double, all being outside rooms; their arrangement permits of flexibility in renting the rooms in suites. The average size of the bedrooms is about 8 feet by 14.6. The studies average 10 by 14.6 feet. All rooms are nine feet high. Each bedroom has a clothes-closet and an enamelled basin with hot and cold water, and is provided with heavy oak furniture. There are four shower-baths on each floor.

The only entrance to each building for students is on the side facing the campus, and leads directly into an assembly room 60 feet square. This room runs up through two stories and has a large open fireplace opposite the entrance.

While Hartley Hall and Livingston Hall are open to all male students of the University, students in Columbia College, in accordance with the desire of the donors, Mrs. Helen Hartley Jenkins and Mr. Marcellus Hartley Dodge, '03, are given the preference in the assignment of rooms in Hartley Hall.

The average weekly charge for a single room is $3.30, or $129 for the academic year of thirty-nine weeks. A pamphlet containing floor plans of the buildings and indicating the charge for each room may be had upon application to the Secretary of the University. The pamphlet contains also the Hall Regulations. Rooms will be assigned in the order of receipt of applications therefor. All such applications should be made in writing on a blank which will be provided by the Superintendent of Buildings and Grounds.

Other Living Accommodations

Besides these dormitories, there are many good boarding-houses and apartments near the University. The careful selection, inspection, and registration of such lodgings, etc., have been undertaken, and a card-catalogue of apartments, rooms, etc., is kept at Earl Hall.

Public Lectures

In addition to the regular courses of instruction, numerous public lectures are given each year by the University. Within the past three years the students of the University and their friends have, among others, been addressed by Professors Wilhelm Bjerknes, Wilhelm Ostwald, Sir Frederick Pollock, Professors William H. Welch, Hendrik A. Lorentz, Hermann Schumacher, Otto Lummer, Joseph Larmor, William James, Rudolf Leonhard, E. B. Titchener, Gilbert Murray, J. W. Jenks, J. C. Gray, Mr. Albert Shaw and President Wilson of Princeton University.

Relations with Other Institutions

The University maintains close relations with the other educational and public institutions of the city, and properly qualified students of the College enjoy unusual privileges at the Metropolitan Museum of Art, the American Museum of Natural History, the New York School of Philanthropy, and the several theological seminaries in or near the city. Students of the University are also frequently given the opportunity to enjoy the most important dramatic and musical performances of the year at a considerably reduced cost. Full information upon these matters is to be found in the University Catalogue for 1907-08, pages 32-34.

St. Paul's Chapel

St. Paul's Chapel, the gift of Olivia Egleston Phelps Stokes and Caroline Phelps Stokes, as a memorial to their parents, was dedicated February 3, 1907. The Chapel is in the form of a cross, the greatest length being 122 feet and the width at the transepts 77 feet. In all 1,050 sittings are provided. Of these, 120 are in the choir, which, as in the English cathedrals, may itself be used for a religious service at which the attendance is small.

Service, at which attendance is voluntary, is held every week-day except Saturday, at noon, the period from 12 to 12.20 being set apart by the University for religious exercises; and on Sunday afternoons at 4 P.M. There are also frequent organ recitals in the Chapel.

Earl Hall

Earl Hall, the home of the religious, philanthropic, and social organizations and interests of the University, is open from 8.30 A.M. to 10 P.M.

daily, to all students without expense, under the direct management of the Secretary of Earl Hall, who is also Secretary of the University Young Men's Christian Association.

The building may not be used for distinctly dogmatic or denominational religious teaching. All organizations the objects of which are to promote the religious and philanthropic life of their student members and of the student body at large have the privilege of holding their meetings in this building. While the social purposes of the Hall are necessarily subordinated to the other uses of the building, the Secretary desires to promote the same type of informal personal and social intercourse that prevails in a good club.

Provision for the regular meetings of student organizations is made, on a day-and-hour schedule, without exclusive use of any of the rooms, in the following order: Societies the purpose of which is (1) primarily religious; (2) primarily philanthropic; (3) primarily literary; and (4) miscellaneous student organizations.

Student Organizations

Academic control of all student organizations, athletic and other, which in any way represent the University before the public, is vested in the University Committee on Student Organizations, appointed by the President. The various organizations, while self-governing, are subject to the regulations of the Committee in respect to their organization, financial management, administration and discipline. The times and places of all public contests and performances must be approved by the Committee. All budgets for expenditure must be approved by the Comptroller of Student Organizations, an officer appointed by the President, and each organization is required to keep an accurate record of its financial operations in the office of the Comptroller. The University Committee on Athletics, also appointed by the President, consisting of three graduates, two students and two officers of the University, has authority to adopt and administer rules of eligibility not involving questions of scholarship and to govern the participation of the students of Columbia University in inter-collegiate athletics. Participation in athletics without the approval of the Committee is forbidden. A pamphlet containing the regulations for student organizations may be obtained from the Secretary of the University.

COLUMBIA COLLEGE

The attention of students is called to the new program of studies in Columbia College by which it becomes to the advantage of the student to enter the courses in Mining, Engineering and Chemistry through Columbia College rather than direct from the secondary school.

While six years are ordinarily required to complete this combined course, it may, under certain conditions, be completed in five years. The student obliged to complete his residence in the shorter period can do so without prejudice to his professional course, but his choice of electives in the College will necessarily be somewhat restricted. He will, however, have a large advantage over the student entering directly upon the professional course without any previous collegiate training and it is hoped that many for whom the six-year course is impossible will avail themselves of this opportunity. In this case the student should note the following suggestions:

(1) He should become a candidate for the degree of Bachelor of Science in Columbia College rather than for the degree of Bachelor of Arts.

(2) He should include among the subjects for entrance to the College:

Entrance Requirements	Prescribed for Bachelor's Degree	
Elementary Chemistry and Elementary Physics	= Natural Science A........	8 points
Advanced Mathematics	= Mathematics A............	6 "
Elementary and Intermediate German, or Elementary and Intermediate French	= German A and B or French A and B...........	12 "

This will anticipate 26 of the 64 "points" of credit prescribed for the Bachelor's degree in Columbia College. (A "point" is normally the equivalent of one hour's attendance at lectures or recitations for a half-year.)

(3) During the first two years at Columbia the 72 points (including all prescribed work) required of candidates who wish to exercise the option of combining collegiate and professional courses may be made up without undue strain as follows:

(*a*) The remaining courses prescribed for the B.S. degree:

English A and B...........................	10 points
History A..................................	6 "
Philosophy A...............................	6 "
Physical Education A and B.................	4 "

4 half-year courses in Science (which may be so chosen as to satisfy certain prescribed first year work of the professional school), aggregating at least....12 points

leaving 34 to be satisfied under (*b*) and (*c*).

(*b*) A limited number of non-technical electives, among which a course in General Economics and in French or German (unless the intermediate requirement in each has been presented at admission) is strongly recommended.

(*c*) Certain additional collegiate electives identical with the remaining first-year courses of the professional school not satisfied by the prescribed work in science mentioned under (*a*).

The student will then be ready to enter the second year of any of the professional courses without conditions: in fact, with a credit for Physical Education B, and to complete the requirements for such professional course in three years. He will receive credit for the degree of B.S. at the end of the fourth year.

The Degree of Master of Arts

The attention of candidates for a professional degree in Applied Science is called to the following provision:

Students holding college degrees, who shall have completed with marked distinction one of the regular courses in the School of Mines, the School of Chemistry, or the Schools of Engineering may be recommended for the degree of Master of Arts; provided that in each case the candidate, while pursuing his professional course, shall have taken additional work, under the direction of the Faculty of Pure Science, to the extent of a major subject, for not less than one academic year.

Every such candidate shall present an essay on some topic previously approved by the professor in charge of his minor subject. Before the candidate is admitted to examination the professor in charge of his major subject must have signified his approval of such essay. This essay must be presented not later than May 1 of the academic year in which the examination is to take place.

The Faculty of Pure Science has charge of all advanced work leading to the degrees of Master of Arts and Doctor of Philosophy in the physical sciences (chemistry, physics, and chemical physics); in the mathematical sciences (pure mathematics, mechanics, mathematical physics, astronomy, and geodesy); and in the natural sciences (mineralogy, lithology, geology, bacteriology, botany, zoölogy, palæontology, physiological chemistry, and physiology); and in engineering (civil, sanitary, mechanical, electrical, and mining) and in metallurgy. The requirements for these degrees and a list of subjects which may be offered for them will be found in the *Announcement of the Faculty of Political Science, Philosophy and Pure Science*. See also page 20.

FELLOWSHIPS

For information as to the fourteen University Fellowships of the annual value of $650 each, and the several endowed fellowships open to qualified candidates for the degree of Master of Arts and Doctor of Philosophy, see the Announcement of the Faculties of Political Science, Philosophy, and Pure Science, or the University Catalogue.

The three following fellowships are of particular interest to students of Mines, Engineering and Chemistry.

Tyndall and Barnard Fellowships

The Tyndall Fellowship for the Encouragement of Research in Physics, endowed by Professor John Tyndall, and of an annual value of $648, and the Barnard Fellowship for Encouraging Scientific Research, endowed by the bequest of the late President Barnard, annual value $500, are awarded annually under the following conditions: The Tyndall Fellowship is available for one or more American pupils who may have shown decided talent in physics, and preferably such as shall express the determination to devote their lives to the advancement of theoretic science and original investigations in that department of learning, and is awarded either to a graduate of the University or to a student in it (not necessarily a candidate for a degree) upon the recommendation of the head of the department of Physics. The Barnard Fellowship is awarded upon the joint recommendation of the Faculties of Columbia College, Applied Science, and Pure Science to a graduate of any one of them who, having shown decided aptness for physical investigation, is disposed to devote himself thereto for some years continuously. The recommendation must in each case be made to the President on or before April 1. The appointment is for the term of one year, but the incumbent shall be eligible to reappointment.

It is the duty of a John Tyndall or Barnard Fellow to devote himself faithfully to the investigation of some subject in physical science at this University, or at some other in this country or abroad, under the supervision of some known physicist approved by the President and the head of the department of Physics. He shall make a report, certified to by the physicist superintending and directing him, quarterly to the President, giving an account of the work in which he has been engaged during the three months preceding.

Adams Research Fellowship

The Ernest Kempton Adams Research Fellowship, founded by Mr. Edward Dean Adams in memory of his son, Ernest Kempton Adams, is of an annual value of $1250. The appointment may be made from among the Faculty, teaching staff, alumni, or students of Columbia University. The incumbent of the fellowship shall prosecute researches

either in Columbia University or elsewhere, in the physical sciences, in psychology, or in their practical applications. The results of the investigations of the incumbent of the fellowship are published and distributed by the University under the title of "Researches of the Ernest Kempton Adams Research Fellows of Columbia University."

SCHOLARSHIPS

Thirty-five scholarships of the annual value of $250 each are available annually for award to meritorious candidates for professional degrees in Mining, Engineering and Chemistry, who are in good academic standing, and in need of pecuniary aid.

Applications for these scholarships should be made in writing, on blanks which will be furnished for the purpose by the Secretary of the University, and should be filed with him on or before May 1.

The awards will be made not later than July 1 by the Committee on Scholarships. Scholarships not allotted at this time, or becoming vacant, shall be filled by the Committee at its discretion.

One half the actual value of the scholarships will be paid at the opening of the academic year, one half at the beginning of the second half-year. Scholars will be required to pay the tuition fees and all other fees.

Scholarships granted in the first year of a student's connection with the University shall be for a half-year only, and shall be continued to those candidates only who have maintained a satisfactory academic standing during that period. Students already holding scholarships in any year must make application in the regular form if they desire to be considered for the succeeding year. No student already holding a scholarship can be considered as a candidate for a second one in that same year.

In recognition of the liberal gifts for the purchase of the site on Morningside Heights which have been received from J. Pierpont Morgan, Cornelius Vanderbilt, D. Willis James, Morris K. Jesup, Samuel D. Babcock, Oswald Ottendorfer, and others, the Trustees have established a number of scholarships, twenty-seven of which are open to students in the Schools under the Faculty of Applied Science, as follow: seven Morgan, seven Vanderbilt, ten James, one Jesup, one Babcock, and one Ottendorfer. These scholarships may be awarded to students who have been in the University for at least one year.

In addition to the above, eight Faculty scholarships may be awarded to members of any class.

Marcus Daly Scholarship in Mining Engineering, etc.

The Marcus Daly Scholarship of the annual value of $1,000, maintained by Mrs. James W. Gerard in memory of her father, is open to

that worker or descendant of a worker in the Montana mines who passes the best competitive entrance examinations for the course in mining engineering. The winner of the scholarship shall hold the same throughout his course in mining engineering, subject to the same conditions of reappointment as those imposed upon the holders of competitive scholarships in Columbia College. As soon as the term of one holder of the scholarship is about to expire, another competitive examination is held. There will be a competition in 1908.

For details concerning the Richard Butler Scholarship, open to male students born in Ohio, see the *Annual Catalogue of Columbia University*, 1907-8, page 395.

MEDALS AND PRIZES

Barnard Medal

A gold medal valued at $200, established by the provisions of the will of President Barnard and endowed by him, known as the "Barnard Medal for Meritorious Service to Science," is awarded quinquennially at Commencement to such person, if any, whether a citizen of the United States or of any other country, as shall within the five years next preceding have made such discovery in physical or astronomical science, or such novel application of science to purposes beneficial to the human race, as in the judgment of the National Academy of Sciences of the United States shall be esteemed most worthy of such honor. The next award will be made in 1910. For a list of previous awards see the *Annual Catalogue of Columbia University* for 1907-8.

Illig Medals

A bequest of $2000 left by William C. Illig, E.M., '82, provides for the annual award of medals at Commencement to the student or students in the graduating class of the Schools under the Faculty of Applied Science who shall, in the judgment of the Faculty, have merited the same by commendable proficiency in their regular studies.

Darling Prize

The Edward A. Darling Prize in Mechanical Engineering, the income of $1000, bequeathed by Edward A. Darling, formerly Superintendent of Buildings and Grounds, shall be awarded annually to the most faithful and deserving student of the graduating class in mechanical engineering, the recipient to be chosen by ballot by members of the graduating class in the Course in Mechanical Engineering from among three names to be chosen by the Faculty of Applied Science.

Academic Calendar

1908-1909

1908—July 7, Tuesday. Ninth Summer Session opens.
August 15, Saturday. Ninth Summer Session closes.

September 7, Monday. Last day for filing applications for entrance examinations.

September 14, Monday. Entrance examinations, and examinations for deficient and debarred students begin.

September 16, Wednesday. Registration begins.

September 22, Tuesday. Registration ceases for students previously matriculated. Later applications received only upon payment of an additional fee of $5.

September 23, Wednesday. First half-year, 155th year begins.

Registration ceases for students matriculating for the first time. Later applications received only upon payment of an additional fee of $5.

Scholars report to the Registrar.

November 3, Tuesday. Election Day, holiday.

November 26, Thursday, to November 28, Saturday, inclusive. Thanksgiving holidays.

December 19, Saturday afternoon, to January 2, 1909, Saturday, inclusive. Christmas holidays.

1909—January 11, Monday. Last day for filing applications for entrance examinations.

January 18, Monday. Mid-year entrance examinations begin.

January 20, Wednesday. Mid-year examinations begin.

January 30, Saturday. First half-year ends.

February 1, Monday. Second half-year begins.

Registration ceases for students entering the second half-year. Later applications received only upon the payment of an additional fee of $5.

Scholars to report to Registrar.

February 22, Monday. Washington's Birthday, holiday.

April 8, Thursday, to April 12, Monday, inclusive. Easter holidays for students in such schools as may be designated by the University Council.

May 1, Saturday. Last day for filing applications for scholarships.

May 10, Monday. Final examinations for candidates for graduation begin.

May 23, Sunday. Baccalaureate service.

May 24, Monday. Class Day.

May 25, Tuesday. Alumni Day.
May 26, Wednesday. Commencement Day.
May 27, Thursday. Final examinations begin.
May 30, Sunday. Memorial Day.
May 31, Monday, holiday.
June 9, Wednesday. Second half-year ends.
June 14, Monday. Entrance examinations begin.

July 7, Wednesday. Tenth Summer Session opens.
August 18, Thursday. Tenth Summer Session closes.

September 13, Monday. Entrance examinations, and examinations for deficient and debarred students begin.

September 15, Wednesday. Registration begins.

September 21, Tuesday. Registration ceases for students previously matriculated. Later applications received only upon payment of an additional fee of $5.

September 22, Wednesday. First half-year, 156th year, begins.

Registration ceases for students matriculating for the first time. Later applications received only upon payment of an additional fee of $5.

Scholars to report to Registrar.

LIST OF ALUMNI
OF THE
SCHOOLS OF MINES, ENGINEERING AND CHEMISTY
OF
COLUMBIA UNIVERSITY
NEW YORK CITY

ABELL, GEORGE H., E.M. 1883
Henley, Wis.

ABENDROTH, WILLIAM P., E.E. 1904
Gen. Ry. Sig. Co., Rochester, N. Y.

ABRAHAM, HERBERT, B.S. (CHEM.) 1903
Chemist Standard Paint Co., Bound Brook, N. J.

ACKEN, J.B., PH.B. (ARCH.) 1894

ACKER, ALBERT J., E.E. 1904
With Crocker-Wheeler Co., Ampere, N. J.

ADAMS, MASON T., E.M. 1901
Pres't Britannia Smelting Co., Britannia Beach, B. C.

ADAMS, RANDOLPH, E.M. 1883
Consulting Mining Engineer, Tennessee Copper Co., Copperhill, Polk Co., Tenn.

ADAMS, W. C., C.E. 1884
31 Nassau St., N. Y. City.

ADAMS, W. J., A.M., E.M. 1878
434 California St., San Francisco, Cal.

AGER, JOHN WINFIELD, MECH.E. 1903
Charleston Navy Yard, Mass.

AGNEW, J. CARSON, E.M. 1904
Asst. Gen. Mgr., Mahoning Ore and Steel Co., Hebbing, Minn.

AGRAMONTÉ, E., C.E. 1886
13 Park Row, N. Y. City.

AGRAMONTÉ, I. E., C.E. 1893
Camagüey, Cuba.

AGRAMONTÉ, JOSÉ CESAR, C.E. 1886
Santa Clara, Cuba.

AIGELTINGER, ARTHUR, E.E. 1907
531 West 113th St., N. Y. City.

ALBERTSON, A.H., PH.B. (ARCH.) 1895
Bangor, Pa.

ALDEN, HERBERT C., E.M. 1884
Yonkers, N. Y.

ALDRICH, C. H., PH.B. (ARCH.) 1893
142 East 33d St., N. Y. City.

ALDRIDGE, WALTER HULL, E.M. 1887
Gen. Mgr. Con. Min. and Sm. Co. of Canada, Trail, B. C.

ALEXANDER, LUDWELL B., MECH.E. 1904
Asst. Engr., United Eng. and Con. Co., N. Y. City.

ALLEN, C. S., PH. (CHEM.), M.D. 1874

ALLEN, ROBERT L., E.M. 1888
102 Cambridge Place, Brooklyn, N. Y.

Alsberg, Julius, A.B., M.E. 1901
Asst. to John Bogert, C.E., N. Y. City.

Ambler, Nathan Babcock, E.E. 1900
344 West 33d St., N. Y. City.

Amy, Ernest Julius Hyacinthe, A.B., E.M. 1885
H. Amy & Co., Bankers, 44-46 Wall St., N. Y. City.

Anderson, George Mendenhall, Ph.B. (Arch.) 1891
18 East 4th St., Cincinnati, Ohio.

Anderson, Norman G., E.M. 1905
Eng. La France Copper Co. and Davis Daly Co., Butte, Mont.

Andresen, Charles Alfred, E.M. 1881
1 South St., Boston, Mass.

Andrews, S. P., Ph.B. (Arch.) 1890
35 West 42d St., N. Y. City.

Andrews, Samuel Wakeman, Jr., Ph.B. 1890
875 Madison Ave., N. Y. City.

Andrews, William C., E.E. 1895
With G. E. Co., Schenectady, N. Y.

Ansbacher, Louis Adolph, Ph.B. (Chem.) 1892
A. B. Ansbacher & Co., 253 Broadway, N. Y. City.

Anthon, C. L., E.E. 1898

Anthony, A., E.E. 1892
100 Reade St., N. Y. City.

Aplington, Henry W., E.M. 1903
Engineering Dept. Hudson Co., N. Y.

Appleby, John Storm, Ph.B., A.M. 1888
216 West 59th St., N. Y. City.

Appleby, W. R., M.A. (Associate) 1887
Prof. of Metallurgy and Dean Minnesota School of Mines, Minneapolis, Minn.

Archbald, Hugh, A.B., E.M. 1907
Scranton, Pa.

Archer, G. F., E.S. 1895
39 Cortlandt St., N. Y. City.

Arden, John L., Ph.B., E.E. 1896
Garrisons, N. Y.

Arendt, Morton, E.E. 1898
Instructor in Electrical Engineering, Columbia University, N. Y. City.

Argall, G. O., E.M. 1905
2700 Humboldt St., Denver, Colo.

Armstrong, Homer, E.M. 1901
Great Falls, Montana.

Arnold, George O., Ph.B., E.M. (Iowa Coll.) 1907
2211 North Nevada Ave., Colorado Springs, Colo.

Arnold, Lawrence S., E.M. 1905
Westbourne Hall, Cheshire, England.

Arnold, Stanfield N., Mech.E. 1904
Yale Club, N. Y. City.

Arnsfield, James J., E.E. 1907
2031 Seventh Ave., N. Y. City.

Arnstein, Leonard A., M.E. 1907
117 East 81st St., N. Y. City.

Aschman, Fred. Theo., Ph.B. (Chem.) 1881
McCance Block, Pittsburgh, Pa.

Ashley, E., M.E. 1905
747 St. Nicholas Ave., N. Y. City.

Atha, Henry Gurney, Ph.B. (Chem.) 1889
Vice-Pres't Benjamin Atha & Co., Newark, N. J.

Atwater, Huntington C., C.E. 1907
1601 Seventeenth Ave., Denver, Colo.

Auerbach, Herbert S., E.M. 1905
40 West 77th St., N. Y. City.

Auryansen, Frederick, C.E. 1896
Piermont, N. Y.

Ayestas, Alberto, Ph.B. (Chem.) 1883
Tegucigalpa, Honduras.

Aylmer-Small, Sidney, E.E. 1899
Instructor Trinity School, N. Y. City.

Ayres, W. C., Ph.B. (Arch.) 1893
156 Fifth Ave., N. Y. City.

Babcock, Dudley P., C.E. 1907
Fanwood, N. J.

Bacon, Daniel R., E.E. 1905
63 Heights Road, Ridgewood, N. J.

Bacot, Oscar Carlos, E.E. 1900

Baer, Herbert Mark, B.S. (Arch.) 1901
40 West 87th St., N. Y. City.

Bailey, Raymond DeWitt, Mech.E. 1907

Baker, George L., Ph.B. 1888

Balch, Samuel Weed, E.M. 1883
Consulting Mechanical and Electrical Engineer, 67 Wall St., N. Y. City.

Baldwin, D. H., C.E. 1895

Baldwin, William M., Ph.B. (Chem.) 1884
Pres't N. Y. Tanning Extract Co., 17 Battery Place, N. Y. City.

Baldwin, William S., E.M. 1903
Gen. Mgr. Kerber Min. and Dev. Co., Villa Grove, Colo.

Bamberger, Sidney M., E.M. 1904
Vice-Pres't Salt Lake and Ogden Ry., Salt Lake City, Utah.

Banks, John Henry, E.M., Ph.D. 1883
Consulting Engineer, 104 John St., N. Y. City.

Bard, Ernest Robinson, E.E. 1900
273 West 11th St., N. Y. City.

Bardwell, A. F., E.M. 1883
Aspen, Colo.

Barling, Harry Brewster, E.M. 1903
Supt. Columbus Borax Co., Griffin, Cal.

Barlow, Elbert S. (Associate), E.E. 1900
Sec. and Treas. Hedden Con. Co., 1 Madison Sq., N. Y. City.

Barnaby, James C., M.E. 1906
280 Manhattan Ave., N. Y. City.

Barnard, Aug. Porter, E.M. 1868
313 West 57th St., N. Y. City.

Barnard, Edward Chester, E.M. 1884
U. S. Geol. Survey, Washington, D. C.

Barnes, W. C., E.E. 1897
200 West 138th St., N. Y. City.

Barnert, Meyer, E.E. 1904
G. E. Co., Schenectady, N. Y.

Barnett, L. H., E.M. 1894
295 Columbus Ave., N. Y. City.

Barratt, Edgar Grant, C.E. 1884
Vice-Pres't Union Bag and Paper Co., 17 Battery Place, N. Y. City.

Barros, Louis de Sousa, E.M., C.E. 1877

Barshell, Frederick B., C.E. 1905
22 West 114th St., N. Y. City.

Bartberger, Edward William, B.S. (Arch.) 1900
408 Pacific Ave., Pittsburgh, Pa.

Barteld, Henry C., E.E. 1907
177 Hancock St., Brooklyn, N. Y. City.

Bartlett, F. R., C.E. 1888
344 Madison St., Brooklyn, N. Y.

Barns, Carl, Ph.D. (Associate) 1877
Dean Graduate Dept. Brown University, Providence, R. I.

Bates, Louis William, E.E. 1900
80 Columbia Heights, Brooklyn, N. Y.

Bates, Putnam A., E.E. 1897
Consulting Electrical Engineer, 42 Broadway, N. Y. City.

Bateson, Charles E. W., E.M., A.M. 1902
Vice-Pres't Josephine Mills, 145 West 58th St., N. Y. City.

Bauchelle, John Fletcher, E.M. 1903
Care J. N. Bauchelle, 78 Murray St., N. Y. City.

Bauernebl, Augusto J., Jr., E.M. 1905
Millers, Nye Co., Nevada.

Baumann, A. P., E.M. 1899
228 East 52d St., N. Y. City.

Baumgarten, Charles, E.E. 1904
With Hawkins Iron Cons. Co., N. Y. City.

Baxter, D. E., C.E. 1897
32 West 60th St., N. Y. City.

Baxter, George S., A.B., E.M. 1868
17 William St., N. Y. City.

Baxter, Harold, E.M. 1906
Goldfield, Nevada.

Bayles, Frederick P., E.M. 1895
Fuel Expert, A. S. & R. Co., Denver, Colo.

Baylis, Roswell S., C.E. 1906
Huntington, N. Y.

Bayne, Howard, E.E. 1901
Treas. Columbia Trust Co., 26 Nassau St., N. Y. City.

Beadel, H. L., B.S. (Arch.) 1898
120 Front St., N. Y. City.

Beans, Hal Truman, B.S., A.M. (Univ. of Nebraska), Ph.D. . . . 1904
Tutor, Anal. Chem., Columbia University, N. Y. City.

Beard, James Thom, E.M., C.E. 1877
Assoc. Editor *Mines and Minerals*, Scranton, Pa.

Beattie, Harold M., E.M. 1907
Mina Las Chispas, Arizpe, Sonora, Mexico, via Naco, Arizona.

Beatty, Alfred Chester, E.M. 1898
Consulting Engineer, 71 Broadway, N. Y. City.

Bechstein, Charles A., Ph.B. 1888
2 West 82d St., N. Y. City.

Beck, Oscar Charles, B.S. (Chem.) 1899
Int. Steam Pump Co., Harrison, N. J.

Becker, Rudolph C., B.S., C.E. 1906
Asst. Engr. Ashokan Reservoir, N. Y.

Beckwith, Charles Ellsworth, Met.E. 1888
Niverville, N. Y.

Beckwith, George Alexander, C.E. 1890
Paterson, N. J.

Beebe, Alfred L., Ph.B. (Chem.) 1880
Portland, Oregon.

Behr, Edward, C.E. 1877
292 Eleventh Ave., N. Y. City.

Behrman, George William, C.E. 1893
143 Rutledge St., Brooklyn, N. Y. City.

Behrman, Samuel, C.E. 1905
61 East 102d St., N. Y. City.

Bellinger, Hiram Paulding, C.E. 1887
Solvay Process Co., Syracuse, N. Y.

Bellman, J. J., E.E. 1897
Pres't of Bellman & Sanford, Engineers and Contractors for Complete Power Plants, 149 Broadway, N. Y. City.

Bemis, F. P., E.M. 1885
109 West 3d St., Davenport, Iowa.

Benedict, Eli, B.S. (Arch.) 1899
Practising Architect, 1947 Broadway, N. Y. City.

Benedict, F. Northrop, C.E. 1904
With N. Y. & L. I. R. R. as Asst. Engr., Parsippany, N. J.

Benedict, V. M., B.S. (Arch.), E.E. 1895
206 West 139th St., N. Y. City.

Benedict, William de Liesseline, E.M. 1874
Consulting Mining Engineer and Metallurgist, 43 Cedar St., N. Y. City.

Benham, Webster L., C.E. 1905
11-14 Binns Bldg., Grand Ave., Oklahoma City, Okla.

Benjamin, Marcus, Ph.B., A.M., Ph.D. 1878
U. S. National Museum, Washington, D. C.

BENNETT, GEORGE L., C.E. 1898
3402 North 19th St., Philadelphia, Pa.

BENTLEY, W. A., E.M. 1898
15 Dey St., N. Y. City.

BENOLIEL, SOL D., E.E. 1896
Gen. Mgr. International Chem. Co., Camden, N. J.

BENSON, HENRY K., A.M., PH.D. 1907
University of Washington, Seattle, Wash.

BERG, WILLIAM N., B.S. (CHEM.) 1904
Assistant in Physiological Chemistry, Columbia University.

BERGER, JOHN, B.S., C.E. 1899
Asst. Engr., Chief Engineer's Office, N. Y. C. & H. R. R. R., N. Y. City.

BERGMAN, HARRY M., C.E. 1907
101 East 78th St., N. Y. City.

BERLINER, RICHARD W., MECH.E. 1901
With V. J. Hedden & Sons' Co., N. Y. City.

BERNHEIM, GEORGE BENJAMIN, B.S. (CHEM.) 1901
R. Neumann & Co., Hoboken, N. J.

BERRY, GEORGE, C.E. 1888
Assistant Engineer, Bureau of Highways, Borough of Brooklyn, N. Y. City.

BERRY, GERALD, C.E. 1889
78 Morton St., Brooklyn, N. Y. City.

BERRY, WILTON GUERNSEY, PH.B. (CHEM.) 1886
Chemist in U. S. Laboratory, N. Y. City.

BETTS, ROMEO T., C.E. 1890
Summit, N. J.

BEYER, ALBIN HERMAN, JR., C.E. 1903
Asst. Engr. Godwin Construction Co., 510 Warwick St., Brooklyn, N. Y. City.

BIEN, JOSEPH RUDOLPH, E.M. 1887
Sec., Julius Bien & Co., N. Y. City.

BIGELOW, LEMUEL C., MECH.E. 1904
Boston Agent, Morse Chain Co., Ithaca, N. Y.

BIGELOW, RICHARD, E.E. 1900
151 Columbia Heights, Brooklyn, N. Y. City.

BIJUR, J., A.M., E.E. 1895
172 West 75th St., N. Y. City.

BINION, JOSHUA, B.S., C.E. 1895
Johannesburg, South Africa.

BIRD, HARRISON KERR, E.E. 1898
Cashier Night and Day Bank, N. Y. City.

BISHOP, HARTWELL, C.E. 1905
31 West 61st St., N. Y. City.

BISHOP, ROY NELSON, E.M. 1902
Supt., Balaklava Copper Co., Kennet, Cal.

BISHOP, R. R., E.E. 1897
Engineer American Telephone and Telegraph Co., Troy, N. Y.

BLACK, ADOLPH, C.E. 1894
Adj. Prof. Civil Engineering, Columbia University, N. Y. City.

BLACK, ALEX. L., E.M. 1890
3932 St. Charles Ave., New Orleans, La.

BLAKE, EDWIN MORTIMER, E.M., PH.D. 1890
Prof. Mathematics and Mech. Engineering, Univ. of Arizona, Tucson, Arizona.

BLEECKER, C. P., E.M. 1881
Supt. and Engineer for R. G. Packard & Co., 130 Pearl St., N. Y. City.

BLEICH, SAMUEL D., B.S., C.E. 1902
Asst. Engr., Rapid Transit Co., N. Y. City, 410 East 52d St., N. Y. City.

BLEYER, ARTHUR, E.E. 1905
With Oberg & Blumberg, Contracting Electrical Engrs., N. Y. City.

BLICKENSDERFER, C., C.E. 1906
1500 Pennsylvania Ave., Denver, Col.

BLISS, COLLINS PECHIN, PH.B. (ARCH.) 1891
University Heights, N. Y. City.

BLISS, H. J. W., A.B., A.M. 1905
10 Cornwall Gardens, London, England.

Blondell, T., Jr., B.S. 1899
18 West 131st St., N. Y. City.

Bloomingdale, Samuel Joseph, B.S. (Arch.) 1901
Third Ave. and 59th St., N. Y. City.

Blossom, Francis, C.E. 1891
Engineer and Contractor, Sanderson & Porter, 52 William St., N. Y. City.

Blum, E., B.S. (Arch.) 1899
1024 Park Ave., N. Y. City.

Blydenburgh, Charles E., A.B., A.M., E.M. 1878
Box 180, Rawlings, Carbon Co., Wyo.

Bode, William A., C.E. 1905
Draftsman, Consolidated Gas Co., N. Y. City.

Bodelsen, O., E.M. 1884
Consolidated Gas Co., foot of West 44th St., N. Y. City.

Boeck, Percy A., B.S. (Chem.) 1907
412 West End Ave., N. Y. City.

Boecklin, Werner, Jr., C.E. 1891
Consulting Engineer, Industrial and Power Plant Engineering, Bowling Green Bldg., N. Y. City.

Boehm, George A., Ph.B. (Arch.) 1897
31 Nassau St., N. Y. City.

Boerner, E. C., Jr., E.E. 1897
Robbins Belt Conveyor Co., 13 Park Row, N. Y. City.

Bogert, Marston T., A.B., Ph.B. (Chem.) 1894
Professor of Organic Chemistry, Columbia Univ., N. Y. City.

Bolles, M. N., B.S., Ph.D. 1903
Chief Chemist, Amer. Sm. and Ref. Co., Monterey, N. L., Mexico.

Bolles, Randolph, Ph.B. (Arch.) 1892

Bolton, Robert, Ph.B. (Chem.), M.D. 1879
408 West 19th St., N. Y. City.

Bond, Stanley F., A.B., E.E. 1907
Asst., Electrical Engineering, Columbia Univ., N. Y. City.

Book, Dwight Dana, C.E., E.E. 1890
16 Front St., Newcastle, Laurence Co., Pa.

Brackett, G. S., M.E. 1898
13 North Smallwood St., Cumberland, Md.

Bookman, S. (Associate), Ph.D. (Chem.), M.A. 1891
Physiological Chemist, Mt. Sinai Hospital, N. Y. City.

Booraem, Robert Elmer, E.M. 1878
Consulting Mining Engineer, 19 West 31st St., N. Y. City.

Borden, William Henry, Jr., Mech.E. 1901
Goldsboro, N. C.

Bordman, D. T., E.M. 1905
Joplin, Mo.

Borsody, Alexander, Mech.E. 1904
325 East 82d St., N. Y. City.

Borsody, Louis, M.E. 1906
337 East 82d St., N. Y. City.

Bos, George Albert, C.E. 1901
112 West 90th St., N. Y. City.

Bossange, E. R., Ph.B. (Arch.) 1893
75 West 45th St., N. Y. City.

Bostwick, William Arthur, Met.E. 1898
Carnegie Steel Co., Pittsburgh, Pa.

Bosworth, W. H., C.E. 1907
51 Jefferson Ave., Brooklyn, N. Y. City.

Bowie, W. B., E.E. 1905
171 Madison St., Brooklyn, N. Y. City.

Bowles, Henry T., E.M. 1904
35 Wall St., N. Y. City.

Boyd, J. D., B.S. (Arch.) 1899
308 West 73d St., N. Y. City.

Boynton, William H., B.S. (Chem.) 1906
Nyack, N. Y.

Brackett, G. S., M.E. 1898
13 North Smallwood St., Cumberland, Md.

Bradley, Alonzo B., E.E. 1903
Construction Dept., Gen. Electric Co., Schenectady, N. Y.

Bradley, Stephen Rowe, Jr., Ph.B. (Chem.) 1890
Vice-Pres't Rockland Light and Power Co., Nyack, N. Y.

Bradley, W. E. F., E.E. 1905
Engineer with Peter Cooper Hewitt, N. Y. City.

Brady, Leon H., E.M. 1904
42 West 75th St., N. Y. City.

Brady, Thomas J., Jr., C.E. 1906
Vice-Pres't of the Thos. J. Brady Co., N. Y. City.

Brandon, Vivian I., E.E. 1901
With New York Telephone Co., N. Y. City.

Braschi, Victor Manuel, Ph.B. (Chem.), E.M., C.E. 1881
Contracting and Machinery Business, City of Mexico.

Braun, Arthur P., E.M. 1907
1615 Monroe St., Toledo, Ohio.

Breneman, Harry Campbell, B.S. (Chem.) 1902
Factory Mgr., Chas. C. Breneman & Co., Cincinnati, Ohio.

Brennan, Andrew Joseph, C.E. 1885

Brereton, Thomas J., A.B., C.E. 1883
Engineer, Cumberland Valley Ry., Chambersburg, Pa.

Brewster, Henry Draper 1883
Brewster & Co., 47th St. and Broadway, N. Y. City.

Bridgham, Samuel Willard, E.M. 1867
49 West 23d St., N. Y. City.

Briesen, Harold V., E.E. 1901
American Telephone and Telegraph Co., N. Y. City.

Brill, Paul K., E.M. 1907
Care El Oro R'way and Min. Co., Ltd., El Oro, Mexico.

Brinley, John Rowlett, C.E. 1884
Firm of Brinley & Holbrook, Civil and Landscape Engineers, N. Y. City.

Britton, Henry Berry, M.E. 1902
255 West 75th St., N. Y. City.

Britton, Nathaniel Lord, E.M., Ph.D. 1879
Director-in-Chief, N. Y. Botanical Garden, N. Y. City.

Brodie, Orrin L., C.E. 1901
Asst. Engr., Board of Water Supply, N. Y. City.

Bronson, Edward Steele, A.B., A.M., E.M. 1867
49 Garden Place, Brooklyn, N. Y. City.

Brooks, W. F., Ph.B. (Arch.) 1893
48 High St., New Britain, Conn.

Brosnan, F. X., C.E. 1891
146 West 74th St., N. Y. City.

Brown, Alexander, E.M. 1897
Builder, N. Y. City.

Brown, Elliott Lockwood, B.S. (Arch.) 1902
614 West 152d St., N. Y. City.

Brown, Hugh Auchincloss, E.E. 1900
64 Orient Way, Rutherford, N. J.

Brown, H. D., C.E. 1898
160 Fifth Ave., N. Y. City.

Brown, Otto, C.E. 1907
125 East 93d St., N. Y. City.

Brown, Robert Gilman, A.B., E.M. 1889
Technical Director, Mining Exploration Co., 28-29 St. Swithin's Lane, London, E. C., England.

Brown, Stanley, E.E. 1902
Weston Elect. Instrument Co., N. Y. City.

Bruckman, Frederick, E.M. 1869
U. S. Mint and 120 West Third Ave., Denver, Col.

Bryce, William, Jr., Ph.B. 1884
20 West 54th St., N. Y. City.

Buchholtz, Gustavus William, C.E. 1901
143 Liberty St., N. Y. City.

Buck, H. W., Ph.B., E.E. 1895
49 Wall St., N. Y. City.

Buck, Victor Buchanan, Jr., Met.E. 1898

Buckingham, Fred. Endicott, E.M. 1884
189 Montague St., Brooklyn N. Y. City.

Buckland, William A., Ph.B. (Arch.) 1890
23 West 24th St., N. Y. City.

Buckley, Charles Ramsay, A.B., A.M., E.M. 1877
29 Broadway, N. Y. City.

Budell, Alfred E., C.E. 1904
Westfield, N. J.

Buell, Thomas R., E.M. 1905
Supt. in Gold Mt. District, Nevada.

Bullman, Charles, Ph.B. (Chem.) 1883
808 Third Place, Plainfield, N. J.

Bultman, H. D., Ph.B. (Arch.) 1895
144 Hewes St., Brooklyn, N. Y. City.

Burbridge, Theodore A., E.M. 1904
Sec. and Treas., Birmingham Car and Mfg. Co., Birmingham, Ala.

Burch, T. Hamilton. Jr., M.E. 1905
Western Electric Co., N. Y. City.

Burden, Henry, 2d, A.B., Ph.B. 1892
Pres. and Treas., Cazenovia Electric Co., and Pres. Cazenovia Canning Co., Cazenovia, N. Y.

Burdette, R. Stuart, E.M. 1907
Grantwood, N. J.

Burns, Abraham Lincoln, E.M. 1887
Engineer, Jabez Burns & Sons, Mfrs. of Coffee and Spice Mill Machinery, N. Y. City.

Burns, Dawson Jabez, E.E. 1900
602 West 146th St., N. Y. City.

Burns, Elmer Z., E.M. 1887
Mining Engineer, firm ot Simonds & Burns, 60 Wall St., N. Y. City.

Burns, William G., E.E. 1898
With Jabez Burns & Sons, Mfrs. of Coffee and Spice Mill Mach'ry, N. Y. City.

Burnside, C. H., B.S. 1898
Madison, Wis.

Burrill, Percy M., E.M. 1896
Bramwell, W. Va.

Burritt, W. W. 1884
Englewood, N. J.

Burroughs, H. S., E.E. 1897
1416 Pacific St., Brooklyn, N. Y. City.

Bush, E. R., E.M. 1881
69 Wall St., N. Y. City.

Bush, William Falkner, E.M. 1885

Busse, Frank A., C.E. 1903
First Asst. Bridge Engineer, L. & N. R. R., Lousiville, Ky.

Bussmann, Arthur Henry, B.S. (Arch.) 1902
186 Chestnut St., Brooklyn, N. Y. City.

Butler, N., E.M. 1880
Glen Ridge, Essex Co., N. J.

Butler, Willard Parker, E.M., LL.B. 1878
Counsellor-at-Law, N. Y. City.

Butler, Willard Parker, E.M., LL.B. 1878
Everett, Wash.

Cabot, George Dodge, E.M. 1903
With Thompson Starrett Co., Building Construction, N. Y. City.

Cabot, John, Jr., E.M. 1899
2643 Broadway, N. Y. City.

Cady, Linius B., E.M., C.E. 1877

Caetini, Don Gelasio, E.M. 1903
Metallurgist, Bunker Hill and Sullivan M. & C. Co., Kellogg, Idaho.

Cairns, Fred. I., Met.E. 1890
Supt. Michigan Smelting Co., Houghton, Mich.

CAIRNS, B. S., A.B., B.S. (ARCH.) 1899
40 Grove St., N. Y. City.

CALMAN, ALBERT, PH.B. (CHEM.), PH.D. 1882
100 William St., N. Y. City.

CAMP, ALBERT ROY, E.M. 1904
Pres. Camp Bros., Auto Touring Co., N. Y. City.

CAMPBELL, ALONZO CLARENCE, E.M. 1869
Asheville, N. C.

CAMPBELL, A. J., E.M. 1898
New London, Conn.

CAMPBELL, WILLIAM, B.Sc., M.Sc., D.Sc. (DURHAM UNIV.), A.M., PH.D. 1903
Adj. Prof. in Metallurgy, Columbia University, N. Y. City.

CANDLER, D. W., PH.B. (ARCH.) 1895
20 Fifth Ave., N. Y. City.

CANFIELD, FREDERICK A., A.B., A.M., E.M. 1873
Mining Engineer, Dover, N. J.

CANFIELD, M. C., E.E. 1893
18 Clinton St., Cleveland, Ohio.

CANNON, HERBERT G., E.M. 1905
Box 1090, Goldfield, Nevada.

CARBO, LUIS A., M.E. 1904
Mechanical Engineer, Guayaquil, Ecuador, South America.

CARBONE, MARIO G., M.E. 1907
102 West 56th St., N. Y. City.

CARLETON, ROBERT A. W., C.E. 1904
Supt. of Construction for R. F. Almirall, N. Y. City.

CARNEY, EDWARD J., C.E. 1896
53 West 68th St., N. Y. City.

CARPENTER, H. C., E.E. 1899
Engineering Dept. of New York Telephone Co.

CARRERE, JOSEPH MAXWELL, C.E. 1883
1 Madison Ave., N. Y. City.

CARRINGTON, WARING, E.M. 1906
801 High St., Newark, N. J.

CARSON, JAMES PETTIGRU, E.M. 1868
Oakley, South Carolina.

CARSON, JOSEPH, C.E. 1890
121 West 55th St., N. Y. City.

CARTER, ALFRED E., B.S. (UNIV. OF NEBRASKA), C.E. 1904
Asst. Eng. Rapid Transit Subway Construction Co., N. Y. City.

CARTER, B. P., E.M. 1895
Box 1021 Johannesburg, South Africa.

CARY, G. B., PH.B. (ARCH.) 1885
184 Delaware Ave., Buffalo, N. Y.

CASAMAJOR, GEORGE H., C.E. 1892
Assistant Editor, *Cosmopolitan Magazine*, N. Y. City.

CASE, A. H., E.M. 1905
San Pedro, New Mexico.

CASEY, EDWARD PEARCE, C.E., PH.B. 1886
Architect, The Alpine, 55 West 33d St., N. Y. City.

CASSARD, WILLIAM JOHN, JR., E.E. 1900
329 West 82d St., N. Y. City.

CASWELL, KENNETH L., B.S. (ARCH.) 1898
114 East 31st St., N. Y. City.

CATRON, JOHN W., E.M. 1904
Santa Fé, New Mexico.

CAUCHOIS, REGINALD W., E.E. 1907
458 West 144th St., N. Y. City.

CAULDWELL, JOHN BRITTON, C.E. 1877
Century Club, 7 West 43d St., N. Y. City.

CHANDLER, HENRY K., E.E. 1906
439 West 123d St., N. Y. City.

CHANNING, JOHN PARKE, E.M. 1883
Pres't Tennessee Copper Co., and Consulting Engineer, N. Y. City.

Chapman, A. W., E.E., A.B. 1894
160 Hicks St., Brooklyn, N. Y. City.

Chapman, H., B.S. (Arch.) 1899
369 West 120th St., N. Y. City.

Chatain, H. G. F. J., E.E. 1897
Care Gen. Electric Co., Schenectady, N. Y.

Chazel, P. E., E.M. 1881
56-58 Broad St., Charleston, S. C.

Chibas, Louis F., E.M. 1898
Engineering Dept., Famento de Olvas Publicos, Santiago de Cuba.

Chisholm, Oliver P., E.M. 1907
Bozeman, Montana.

Church, Elihu Cunyngham, C.E. 1904
Asst. in Civil Engineering, Columbia University, N. Y. City.

Church, Elihu Dwight, Jr., E.M. 1887
Secretary Church & Dwight Co., N. Y. City.

Church, John Adams, A.M., E.M., Ph.D. 1867
Consulting Mining Engineer, 15 William St., N. Y. City.

Church, John Adams, Jr., E.M. 1906
With Guanajuato Development Co., Guanajuato, Mexico.

Churchill, Lewis T., C.E. 1905
Foreman for H. C. Van Emburgh, C.E., Plainfield, N. J.

Clark, Allan J., E.M. 1896
Assayer and Metallurgist, Homestake Mining Co., Lead, S. D.

Clark, Benjamin Franklin, Jr., M.E. 1902
Chief of Eng. and Draft'g Dept., Taylor Iron and Steel Co., High Bridge, N. J.

Clark, Carle Dawes, E.M. 1901
With Bewick, Moreing & Co., 62 London Wall, E. C., London, England.

Clark, Charles Martin, E.E. 1897
Clark & MacMullen, Engineers, 20 Broad St., N. Y. City.

Clark, D. L., C.E. 1890
Cardenas, Cuba.

Clark, Edwin Perry, E.M. 1880
Att'y and Counsellor-at-Law, with Title Guar. and Trust Co., Brooklyn, N. Y.

Clark, Edmund, M.S. 1892
Food Inspector, Chemist, U. S. Dept. of Agriculture, N. Y. City.

Clark, Francis M., E.M. 1905
Cosmos Club, San Francisco, Cal.

Clark, Franklin S., E.M., Ph.D. 1885
Pres't Georgia Pine Turpentine Co. of New York.

Clark, Frederick H., E.M. 1907
Supt. San Cayetano Mines, Ltd., Guanajuato, Mexico.

Clark, George Hallett, C.E. 1893
Senior Asst. Engineer and Eng'r 1st Div. Rapid Transit Com., N. Y. City.

Clark, Josiah Huntoon, E.M. 1897
Member of firm Henry I. Clark & Co., N. Y. City.

Clark, Leroy, Jr., E.E. 1894
114 Liberty St., N. Y. City.

Clarke, Robert Walter Maxwell, Mech.E. 1902
With N. Y. Steam Fitting Co., N. Y. City.

Clark, Walter Lemuel, Mech.E. 1901
With Francis Bros. & Jellett, Consulting Engineers, N. Y. City.

Clark, W. G., E.E. 1899
73 East 92d St., N. Y. City.

Clarkson, Julian Gerard, C.E. 1907

Clayton, William Robert, Ph.B. (Arch.) 1890
With Toledo White Lead Co., Toledo, Ohio.

Clinch, Edward Sears, Jr., E.E. 1900
64 Orawaupum, White Plains, N. Y.

Close, Joseph Atwater, C.E. 1902
Asst. Engr., Panama R. R., Panama.

Cloud, Leo George, A.B., E.M. 1879
Newport, Ky.

Cobleigh, William M., E.M., A.M. 1899
Professor Montana State Coll. Agriculture, Bozeman, Mont.

Coelus, Jules Auguste, C.E. 1904
Sec. and Treas. Thos. J. Brady Co., B'lders and Gen'l Contractors, N. Y. City.

Coffin, Tristram Robert, C.E. 1898
McKinnell, Coffin & Rawlins, Bonds, N. Y. City.

Cogan, H. M., E.E. 1899
456 Eightieth St., Brooklyn, N. Y. City.

Coggeshall, A. C., E. E. 1903
Asst. Prof. Elect. Eng., Ohio State University.

Cohen, Louis J., B.S., M.S., Ph.D. 1907
50 West 129th St., N. Y. City.

Cokefair, Francis A., C.E. 1894
Chief Engineer, Great Northern Power Co., Duluth, Minn.

Colby, Albert Ladd, Ph.B. (Chem.) 1881
Chemist and Consulting Metallurgist, 217 West 110th St., N. Y. City.

Collens, Clarence L., 2d, E.E. 1897
Asst. Supt. Canadian Niagara Power Co., Niagara Falls, N. Y.

Collins, Francis W., B.S., E.M. 1905
With Halbert P. Gillette, 11-21 Park Row, N. Y. City.

Colman, Jerome M., E.M. 1901
165 West 140th St., N. Y. City.

Colt, Morgan, B.S. (Arch.) 1901
44 Stuyvesant St., N. Y. City.

Colt, S. B., Ph.B. (Arch.) 1888
287 Fourth Ave., N. Y. City.

Colton, Charles Adams, E.M. 1873
Director and Instructor in Chemistry and Physics, Newark Technical School, Newark, N. J.

Colton, Frederick Gray, Ph.B. (Arch.) 1890
136 Montague St., Brooklyn, N. Y. City.

Colwell, Lino M., B.S., Mech.E. 1901
312 West Seventh Ave., Columbus, Ohio.

Comstock, Claude Nichols, C.E. 1888

Comstock, F. L. 1896
Gloversville, N. Y.

Conant, Henry Dunning, E.M. 1886
Supt. The Lake Superior Smelting Co., Dollar Bay, Mich.

Congdon, Ernest Arnold, Ph.B. (Chem.), F.C.S. 1887
Chemist to New York Board of Health, 117 West 82d St., N. Y. City.

Congdon, H. W., Ph.B. (Arch.) 1898
18 Broadway, N. Y. City.

Connell, W. H., Jr., M.E. 1905
7 Colonial Place, Pittsburgh, Pa.

Conover, John T., E.E. 1898
62 Cedar St., N. Y. City.

Constant, Charles Louis, E.M., C.E. 1877
Consulting Engineer, 61 Beekman St., N. Y. City.

Constant, Charles L., Jr., E.M. 1904
With C. L. Constant, 61 Beekman St., N. Y. City.

Cook, Frederick S., E.M. 1905
Consulting Engineer, Joplin, Mo.

Cook, Thomas F., Mech.E. 1904
With Lackawanna Steel Co., Buffalo, N. Y.

Cooper, William Hamilton, Ph.B. (Chem.) 1882

Corbet, William W., Ph.B. (Yale), E.M. 1904
Engineer with Corbet & Smythe, Civil and Mining Engineers, Santa Fé, N. M.

Corcoran, J. T., E.M. 1884
Cedarhurst, N. Y.

Cornell, George B., E.M., C.E. 1877
20 Broad St., N. Y. City.

Cornell, Milton L., C.E. 1905
Mgr. of Plant for the J. B. & J. M. Cornell Co., N. Y. City.

Cornell, Russell Todd, E.M. 1901
67 West 83d St., N. Y. City.

Cornwall, George Rockwell, E.M., C.E. 1876
Rye, Westchester Co., N. Y.

Cornwall, Henry Bedinger, A.B., A.M., E.M., Ph.D. 1867
Prof. of Applied Chemistry and Mineralogy, Princeton Univ., Princeton, N. J.

Cornwall, H. C., E.M. 1879
49 Maiden Lane, N. Y. City.

Cosgrove, John D., C.E. 1906
Engineer Hudson Companies, Hudson River Tunnels, New York.

Coursen, George Hampton, E.M., C.E. 1868
672 Lexington Ave., N. Y. City.

Covell, E. C., A.B. 1892
Cazenovia, N. Y.

Covell, W. S., Ph.B. (Arch.) 1893
152 Broadway, N. Y. City.

Cox, E. V., E.E. 1895
967 Madison Ave., Plainfield, N. J.

Cox, Harold N., B.S. (Chem.) 1904
730 Jefferson Ave., Brooklyn, N. Y. City.

Cox, Jennings Stockton, Jr., Met.E. 1887
Sec. and Treas., Pompo Manganese Co., Santiago de Cuba.

Coykendall, Edward, C.E. 1895
Rondout, N. Y.

Coykendall, Frank, C.E. 1901
Rondout, N. Y.

Coykendall, Frederick, A.B., A.M., C.E. 1897
Sec. and Gen. Mgr. Cornell Steamboat Co., N. Y. City.

Coykendall, Thomas Cornell, C.E. 1890
Rondout, N. Y.

Cozzens, Harmon, E.M. 1885
Colo. Fuel and Iron Co., Pueblo, Colo.

Cramer, Stuart W., E.M. 1889
Contractor, Charlotte, N. C.

Crampton, S. H., E.E. 1897
Asst. Supt. Eng., N. Y. Telephone Co.

Crawford, H. E., E.M. 1899
343 Bradbury Bldg., Los Angeles, Cal.

Cregier, Abbott Morgan, M.E. 1901
Engineer Fibre Conduit Co., Orangeburg, N. Y.

Crissey, Clarence Philip, M.E. 1902
Asst. Engr., Steam Turbine Dept., Gen. Elect. Co., Lynn, Mass.

Cristy, Edward Buxton, Ph.B. (Arch.) 1891
Albuquerque, New Mexico.

Crocker, Francis Bacon, E.M., Ph.D. 1882
Professor of Electrical Engineering, Columbia University, N. Y. City.

Cromwell, James William, Jr., Ph.B. 1889
Architect, 28 East 21st St., N. Y. City.

Cromwell, Robert Hewitt, E.M. 1902
Supt. Minas, Las Chiapas Arizpe, Sonora, Mexico.

Crowell, Francis S., C.E. 1905
188 Franklin Place, Flushing, N. Y. City.

Cruser, Frederick Van Dyke, B.S. 1903
Chemical Engineer, Union Metallic Cartridge Co., Bridgeport, Conn.

Curry, Malcolm, Mech.E. 1903
Mech. Eng. of Willimantic Mills, American Thread Co., Willimantic, Conn.

Curry, Robert, B.S. (Arch.) 1900
1284 Dean St., Brooklyn, N. Y. City.

Curtis, C. C., A.B., A.M. 1892
120 Liberty St., N. Y. City.

Curtis, Charles Gordon, C.E. 1881
85 Liberty St., N. Y. City.

Cushman, Alex. R., Ph.B., Ph.D. 1878
132 East 16th St., N. Y. City.

Daly, Edwin Howell, E.E. 1898
Equipment Dept., New York Navy Yard.

Daniels, Harold Platt, E.E. 1902
Engineer, Peet & Powers, N. Y. City.

Dantziger, C. T., E.M. 1905
Engineer, Minnie Healy Mine, Butte, Mont.

Danziger, Joseph Louis, B.S. (Chem.) 1902
Chief Chemist and Assayer, International Ore Treating Co., N. Y. City.

Darrach, J. M. A., Ph.B. (Arch.) 1896
317 West 58th St., N. Y. City.

Darwin, Harry Gilbert, E.M. 1887
210 West 107th St., N. Y. City.

Davidson, William Stewart, E.M. 1897
Mgr. of Clarkson & Co., Port Arthur, North China.

Davis, Charles Henry, C.E. 1887
R. R., mining, manufact'g and real estate enterprises, South Yarmouth, Mass.

Davis, William Monroe, E.M. 1890
235 East Genesee St., Syracuse, N. Y.

Day, Salisbury M., E.E. 1904
R'way Signal Co., N. Y. City.

De Coppet, T., B.S. (Arch.) 1897
30 Broad St., N. Y. City.

Deghuee, Joseph Albert, Ph.B., A.M., Ph.D. 1890
Vice-Pres't Lederle Laboratories, N. Y. City.

De Huff, Arthur I., E.M. 1907
101-102 Van Volkenburg Block, Spokane, Washington.

Del Calvo, Francis, C.E. 1884
P. O. Box 1510, N. Y. City.

Del Rio, Jose Ramoux, M.E. 1906
La Principal, Santiago de Cuba.

Delson, I., C.E. 1899
Asst. Engr., Dept. of Bridges, N. Y. City.

De Luze, Louis Philippe, C.E. 1879
Asst. Engr., Rapid Transit R. R. Com., N. Y. City.

Demeritt, Harold S., E.E. 1904
New Canaan, Conn.

Dempwolf, Charles H., Jr., B.S. (Chem.) 1903
York Chemical Works, York, Pa.

Denison, Griswold, 2d, M.E. 1904
With P. R. Moses, Consulting Engineer, N. Y. City.

Denton, Frederick Warner, C.E. 1889
Gen. Mgr. Champion Copper Co., Agent Boltes Mining Co., Agent Trimountain Mining Co., Michigan.

Derleth, Charles, Jr., B.S., C.E. 1896
Professor of Structural Engineering, Univ. of California, Berkeley, Cal.

Derleth, Walter T., B.S., C.E. 1904
Engineer for D. J. Ryan, Contractor, Brooklyn, N. Y. City.

Detwiller, Charles H., Ph.B. (Arch.) 1885
99 Nassau St., N. Y. City.

Deutsch, Maurice, C.E. 1906
Asst. Engr., The Foundation Co., 35 Nassau St., N. Y. City.

Devereux, Walter Bourchier, A.B., A.M., E.M. 1878
Consulting Mining Engineer, 99 John St., N. Y. City.

Dewey, F. H., Ph.B. (Arch.) 1895
Mexico, N. Y.

Diamant, Sidney, E.E. 1902
Engineering Dept., Board of Education, N. Y. City.

Dickerson, F. Secor, E.E. 1899
Vice-Pres't Glen Engineering Construction Co., N. Y. City.

Dickie, Albert Ernest, B.S. (Chem.) 1902
Instructor in Chemistry and Mech. Drawing, High School, Torrington, Conn.

Dickinson, Harold Thomas, E.M. 1900
Manager De Beers Mine, Kimberley, South Africa.

Dickson, Charles F., C.E. 1907
519 Main St., Cincinnati, Ohio.

Dickson, Charles W., Ph.D. 1903
Lecturer in Chemistry, School of Mining, Kingston, Ontario, Canada.

Dieterich, A. E., C.E. 1899
963 Fifth Ave., N. Y. City.

Dittenhoefer, Lester Frank, Mech.E. 1903
Counsellor-at-Law, N. Y. City.

Dixon, James, E.E. 1901
Electrical Contractor, 14th St. and Vernon Ave., Long Island City.

Dobbins, Max, E.M. 1895

Dodge, Francis Despard, Ph.B. (Chem.), Ph.D. 1888
With Dodge & Olcott Co., N. Y. City.

Dodsworth, W. A., Ph.B. (Chem.) 1888
Hamilton Ave., Englewood, N. J.

Dolan, Charles F., C.E. 1902
New Rochelle, N. Y.

Dominick, William Francis, B.S. (Arch.) 1901
35 East 57th St., N. Y. City.

Donnell, H. E., Ph.B. (Arch.) 1887
225 Fifth Ave., N. Y. City.

Donnelly, Thomas F., E.M. 1907
412 West 149th St., N. Y. City.

Donovan, Percy W., E.M. 1905
Supt. of Exploration for E. J. Longyear, Hibbing, Minn.

Doolittle, Charles Horace, E.M. 1885
P. O. Box 1534, Salt Lake City, Utah.

Doty, Archibald, E.E. 1907
69 Locust Hill Ave., Yonkers, N. Y.

Doty, Henry S. (Chem.) 1905
69 Locust Hill Ave., Yonkers, N. Y.

Doud, Charles H., A.B., E.E. 1901
150 Nassau St., N. Y. City.

Dougherty, Richard Erwin, C.E. 1901
With Construction Dept., N. Y. C. & H. R. R. R., Middle Division.

Doughty, John B., C.E. 1906
Asst. Inspector, Bridge Dept., L. I. R. R., N. Y.

Douglas, Edward M., C.E. 1881
Topographer, U. S. Geol. Survey, Washington, D. C.

Douglas, John Sheafe, C.E. 1890
Berrian & Douglas, 22 Thames St., N. Y. City.

Dow, Allen Wade, Ph.B. (Chem.) 1888
Dow & Smith, Chemical Engineers, 24-26 East 21st St., N. Y. City.

Dowie, Horace, A.B., E.E. 1896
363 Jefferson Ave., Brooklyn, N. Y. City.

Downing, Orrien Pinkerton, Ph.B. 1878
Consulting Chemist, 116 Battery St., San Francisco, Cal.

Downs, William Fletcher, E.M. 1882
Consulting Engineer, 75 Fairview Ave., Jersey City, N. J.

Drasel, Charles, E.M. 1895
56 Bowers St., Jersey City, N. J.

Druding, Frank D., E.M. 1906
Utah Copper Co., Bingham, Utah.

Drummond, Isaac Wyman, E.M., Ph.D. 1878
Chemist and Director, F. W. Devoe and C. T. Raynolds Co., N. Y City.

Duden, Frederick H., Met.E. 1906
Bronxville, N. Y.

Duden, William, E.E. 1904
Bronxville, N. Y.

Dufourcq, Edward Leonce, E.M. 1892
Consulting Mining Engineer, Produce Exchange Bldg., N. Y. City.

Dunham, Edward Kellogg, Ph.B. (Chem.) 1881
Prof. of Pathology in Univ. and Bellevue Hospital Medical College, N. Y. City.

Dunlop, William C., M.E. 1906
Erecting Engineer, Allis Chalmers Co., 71 Broadway, N. Y. City.

Dunn, A. D., E.E. 1898
164 East 111th St., N. Y. City.

Dunn, Drew H., E.M. 1905
Ford Place, Pasadena, Cal.

DUNN, GANO SILLICK, M.S., E.E. 1891
Vice-Pres. American Institute Electrical Engineers, Engineer Crocker-Wheeler Co., Ampere, N. J.

DURHAM, EDWARD B., E.M. 1892
Chief Draftsman, Trenton Iron Co., Trenton, N. J.

DURHAM, HENRY WELLES, C.E. 1895
Resident Engr. Panama Water Wks., Isthmian Canal Com., Ancon, Canal Zone.

DURHAM, L., C.E. 1899
404 West 145th St., N. Y. City.

DUSENBERRY, ARTHUR NEWCOMB, E.E. 1900
1 West 81st St., N. Y. City.

DUSENBERRY, WALTER LORTON, M.E. 1884
Engineer to the Commissioners of Accounts, N. Y. City.

DUTCHER, B. H., PH.B. (CHEM.) 1892
Surgeon, U. S. A., Ft. Santiago, Manila, Philippine Islands.

DWIGHT, ARTHUR SMITH, E.M. 1885
Consulting Engineer, 25 Broad St., N. Y. City.

DYER, H. P., E.M. 1905
Vandalia Coal Co., Linton Co., Indiana.

EARLE, ARTHUR WINTHROP (ASSOCIATE) 1877
Winchester Repeating Arms Co., New Haven, Conn.

EASTON, L. C., C.E. 1884
518 Bradbury Bldg., Los Angeles, Cal.

EASTWICK, EDWARD P., JR., PH.B., C.E. 1889
Supt. Amer. Sugar Ref. Co., 807 Common St., New Orleans, La.

EASTWICK, GEORGE SPENCER, C.E. 1879
University Club, N. Y. City.

EBERHARDT, WILLIAM G., E.M. 1891
450 West 22d St., N. Y. City.

ECCLES, DAVID CHARLES, B.S. (CHEM.) 1900
Consulting Chemist, 191 Dean St., Brooklyn, N. Y. City.

ECKERSON, CHARLES H., E.M. 1898
Consulting Engineer, Englewood, N. J.

EDDIE, E. C., E.M. 1885

EDDINGFIELD, FRANK T., E.M. 1906
Supt. Emery Mine, Deerlodge, Montana.

EDWARDS, RICHARD MASON, E.M. 1886
Agent, Franklin Mining Co., Houghton, Mich.

EHRENREICH, J. J., E.E. 1899
Consulting Engineer, 13 East 30th St., N. Y. City.

EILERS, KARL EMRICH, E.M. 1889
Consulting Engr. and Director of Amer. S. and R. Co., 71 B'way, N. Y. City.

ELIOT, WALTER GREAME, E.M., C.E., PH.B., PH.D. 1878
University Club, N. Y. City.

ELLIOTT, ARTHUR HENRY, PH.B. (CHEM.), PH.D. 1881
Engineer-Chemist to Consolidated Gas Co., N. Y. City.

ELLIOTT, ROBERT HUGER, B.S. (ARCH.) 1900
3903 Sansome St., Philadelphia, Pa.

ELLIOTT, WILLIAM, PH.B. 1880
522 West End Ave., N. Y. City.

ELLIS, A. VAN HORN, C.E. 1889
Westchester, N. Y. City.

ELSING, MORRIS J., E.M. 1907
Care Copper Queen, Bisbee, Arizona.

EMANUEL, L. V., E.M. 1896
Asst. Supt. Lead Refin'g and Parting Plant, Amer. S. and R. Co., Maurer, N. J.

EMERY, G. H., PH.B. 1894
Nyack, N. Y.

ENGEL, LOUIS GEORGE, E.M. 1880
C. Von Goeben & Engel, Engineers and Contractors, Brooklyn, N. Y. City.

ENGLEHARDT, EUGENE NICHOLAS, E.M. 1885
Asst. Supt., Selby Smelting and Lead Co., Selby, California.

ENOS, HERBERT C., E.M. 1906
Mgr. of Tehuantepec Silver Mines Co., San Geronimo, Estado de Oaxaca, Mex.

Ents, G. G., B.S. (Arch.) 1899
24 East 83d St., N. Y. City.

Ernest, R. H., E.M. 1905
263 South Logan Ave., Denver, Colo.

Escobar, Francisco, E.M. 1889
Jopling & Escobar, Engineers, Cuyahoga Bldg., Cleveland, Ohio.

Evans, Alfred W., E.M. 1906
The Grange, Westerham, Kent, England.

Evans, I. N., C.E. 1895
Consulting Engineer, 281 Water St., N. Y. City.

Everett, Samuel H., Jr., E.E. 1903
With Gould Storage Battery Co., N. Y. City.

Faber, John Pelham, Mech.E. 1903
Chief Draftsman, Ransome Concrete Machinery Co., N. Y. City.

Fabian, Francis G., M.E. (Cornell), E.M. 1907
1509 Ridge Ave., Evanston, Ill.

Fahys, G., C.E. 1884
54 Maiden Lane, N. Y. City.

Falk, D. B., C.E. 1882
Charleston, S. C.

Falk, Kaufman George, B.S. (Chem.) 1901
Tutor in Physics, Columbia University, N. Y. City.

Falk, Milton J., B.S. (Chem.) 1904
16 East 81st St., N. Y. City.

Falk, Myron Samuel, C.E., M.E., Ph.D. 1899
Consult'g Eng. and Chief Eng. Godwin Con. Co., 60 Wall St., N. Y. City.

Farmer, Alex. S., C.E. 1897
Asst. Eng. on Jerome Park Reservoir, Aqueduct Commissioners, N. Y. City.

Farrer, Henry E., E.E. 1907
205 Sunnyside Ave., Brooklyn, N. Y. City.

Fearn, Percy Le Roy, E.M. 1889
Consulting Engineer, Abangarez Gold Fields, Costa Rica.

Fechheimer, A. L., B.S. (Arch.) 1899
2359 Park Ave., Walnut Hills, Cincinnati, Ohio.

Feldman, Max, C.E. 1900
P. O. Box 503, Rosebank, L. I.

Fellows, William K., Ph.B. (Arch.) 1894
1733 Marquette Bldg., Chicago, Ill.

Fenner, Clarence Norman, E.M. 1892
Consulting Engineer, Paterson, N. J.

Ferenczy, Arthur, A.B., E.E. 1906
245 West 24th St., N. Y. City.

Ferguson, G., C.E. 1898
Salamanca, N. Y.

Ferguson, George Albert, Ph.B. (Chem.) 1890
303 Stuyvesant Ave., Brooklyn, N. Y. City.

Ferguson, Samuel, B.S., E.E. 1899
24 State St., Schenectady, N. Y.

Ferguson, William C., Ph.B. (Chem.) 1887
Laurel Hill Chem. Wks., Laurel Hill, N. Y.

Ferrer, Carlos Ferrer, C.E. 1883
Sta. Lucia alta 8, Santiago de Cuba.

Ferris, Junius Colton, E.M. 1883
Carthage, Ill.

Fettretch, Charles S., E.E. 1906
335 West 88th St., N. Y. City.

Feuchtwanger, Henry, Ph.B. 1882
Madison, N. J.

Feust, Arthur, E.M. 1902
Engineer for I. O. T. Co., N. Y. City.

Fiallos, E. C., C.E. 1883
No. 27 Calle 10 A., Tegucigalpa, Honduras, C. A.

Fies, Milton H., E.M. 1904
Supt. Sayreton & Thompson Mines, Alabama.

Finch, James Kip, C.E. 1906
Instructor in Railroad Eng. and Surveying, Lafayette College, Easton, Pa.

Finlay, George Irving, A.B., Ph.D. 1903
134 Flatbush Ave., Brooklyn, N. Y. City.

Fischer, Siegfried, B.S. 1907

Fisher, Henry, B.S. (Chem.) 1899
E. H. Cunningham & Co., Sugar Land, Texas.

Fisher, Lloyd Weigand, Ph.B. (Arch.) 1890
109 East 28th St., N. Y. City.

Fisher, T. E., E.M. 1905
Guanajuato Cons. Mine Co., Guanajuato, Mexico.

Fisher, Willard, E.M. 1888
Agent, Illinois Zinc Co. and Star Engravers' Supply Co., N. Y. City.

Fitch, Charles Lincoln, E.M. 1882
253 Throop Ave., Brooklyn, N. Y. City.

Fitch, Josiah Huntington, E.M. 1884
Municipal Bldg., Tremont, N. Y. City.

Fitzgerald, George, E.M. 1884
Care Federal Copper Co., 261 Broadway, N. Y. City.

Fleissner, Gustav L., E.M. 1907
246 East 4th St., N. Y. City.

Fletcher, G. W., E.E. 1895
107 Liberty St., N. Y. City.

Fliess, Robert A., E.E. 1899
Pres. Combined Experimental and Manufacturing Co., Newark, N. J.

Floyd, F. W., C.E., E.M. 1877
742 East 12th St., N. Y. City.

Focardi, Pierre L., B.S., E.E., M.E. 1901
Chief Draftsman, N. J. Foundry and Machine Co., N. Y. City.

Foerster, David, E.M. 1895
120 West 5th St., Cincinnati, Ohio.

Folger, E. P., C.E. 1894
80 Quincy St., Brooklyn, N. Y. City.

Foote, E., Jr., E.E. 1898
Care J. S. Bache & Co., 42 Broadway, N. Y. City.

Foote, Francis S., Jr., E.M. 1904
Asst. Engr. N. Y. C. & H. R. R. R., N. Y. City.

Force, D. W., Jr., E.E. 1897
Montclair, N. J.

Ford, Harry C., C.E. 1900
Engineer for Rodgers Contracting Co., N. Y. City.

Ford, Walter H., C.E. 1903
Francis W. Ford & Sons, City Surveyors, N. Y. City.

Forst, Leo B. (Chem.) 1906
Asst. Chemist, Internal Revenue, Treasury Dept.

Foster, O. R., Met.E. 1899
549 Monroe St., Brooklyn, N. Y. City.

Foster, Pell W. 1883
Pres. Power Specialty Co., 111 Broadway, N. Y. City.

Foster, Reginald Guy, C.E. 1893
Structural Engineer, 554 West 114th St., N. Y. City.

Fowler, A. C., C.E. 1889
Cienfuegos, Cuba.

Fowler, Lawrence Hall, A.B., B.S. (Arch.) 1902
Care Judge Fowler, Baltimore Co., Md.

Fowler, Samuel Stewart, A.B., E.M. 1884
Consulting Engineer and General Manager Canadian Metal Co., B. C.

Fox, M. J., Ph.B. 1895
11 East 59th St., N. Y. City.

Foye, Andrew Ernest, C.E. 1890
Sec., Treas. and Director Ryan-Parker Con. Co., 21 Park Row, N. Y. City.

Frambach, C. L., E.M. 1905
Chebengan, Mich.

Franc, Carl B., Jr., E.M. 1906
648 Tenth Ave., Brooklyn, N. Y. City.

FRANCKE, ROBERT OTTO, C.E. 1880
W. Passburg, Esq., Moscow, Russia.

FRANK, ALBERT, E.M. 1906
Sombrerete Min. Co., Sombrerete, Zac., Mexico.

FRANK, AUGUSTUS ALPHONSUS, E.E. 1900
Care N. Y. and N. J. Telephone Co., Brooklyn, N. Y. City.

FRANK, EUGENE, MECH.E. 1903
Electrical and Mechanical Engineer, 209 West 127th St., N. Y. City.

FRANK, HENRY, B.S. (CHEM.) 1903
378 Vanderbilt Ave., Brooklyn, N. Y. City.

FRANK, JEROME WILLIAM, PH.B. (CHEM.) 1888
Vice-Pres., Ancrum Paper Mills, N. Y. City.

FRANKFIELD, EMIL, C.E. 1886
38 West 34th St., N. Y. City.

FRANKLIN, L. M., JR., PH.B. (ARCH.) 1896
Flushing, L. I.

FRANKLIN, MILTON W., M.D., M.A. 1906
Engr. United Rico Mines Co., Rico, Colo.

FREEDMAN, WILLIAM HORATIO, C.E., E.E. 1889
Professor of Electrical Engineering, University of Vermont, Burlington, Vt.

FREUND, HARRY PAUL, E.E. 1902
With Reis & O'Donovan, Engineers and Contractors, N. Y. City.

FREUND, MORTIMER, E.E. 1906
With Westinghouse Electric and Mfg. Co., East Pittsburg, Pa.

FRIEDLAND, JACOB M., B.S., C.E. 1907

FRIEDMAN, SAMUEL, C.E. 1892
Tuscaloosa, Ala.

FRIEDMAN, WILLIAM H., E.E. 1907
172 Rivington St., N. Y. City.

FRISBEE, H. D., E.E. 1894
1340 Fulton Ave., Bronx, N. Y. City.

FUENTE, JESUS DE LA, E.M. 1900
Hornas, Coahuila, Mexico.

FUENTES, PAUL, E.M. 1894
321 Hudson St., Hoboken, N. J.

FULTON, CHARLES H., E.M. 1897
Consulting Engineer, Standard Sm. Co., and Pres. State School of Mines, Rapid City, South Dakota.

FULTON, CHESTER A., E.M. 1906
Rapid City, South Dakota.

FULTON, JOHN ALLEN, E.M. 1900
Reno, Nevada.

GAGE, SAMUEL EDSON, PH.B. (ARCH.) 1887
3 Union Square, N. Y. City.

GALLATIN, A. R., A.B., E.E. 1898
58 West 55th St., N. Y. City.

GARCELON, CHARLES R., JR., C.E. 1902
North Lovell, Oxford Co., Maine.

GARDINER, CHARLES R., C.E. 1907
2307 Seventh Ave., N. Y. City.

GARDNER, WALTER, E.M. 1907
Care Copper Queen Cons. Mining Co., P. O. Box 1955, Bisbee, Arizona.

GARDNER, WATTS DENNING, C.E. 1888
5 West 101st St., N. Y. City.

GARLICHS, HERMAN, E.M. 1880
Supt. Perth Amboy Plant Amer. S. & R. Co., Maurer, N. J.

GARRISON, EDMUND HOYT, E.M., C.E. 1876
84 Highland St., Yonkers, N. Y.

GARTENSTEIG, CHARLES, B.S. 1895
Asst. Engr., Dept. Highways, Borough of the Bronx, N. Y. City.

GASTON, MELCHER E., A.B., B.S., C.E. 1902
Cardenas, Cuba.

GAY, FRAZER W., A.B., E.E. 1906
Specification Dept., Crocker-Wheeler Co., Ampere, N. J.

GEER, GEORGE JARVIS, JR., E.M. 1868
71 Grand St., N. Y. City.

GEIGER, A. W., E.M. 1905
Alaska S. & R. Co., Hadley, Alaska.

GEPPERT, R. M., E.M. 1898
Tonopah, Nevada.

GIBERT, FREDERICK E., E.M. 1906
627 West 115th St., N. Y. City.

GIDDINGS, EDWARD EVERETT, E.M. 1867
712 Royal Insurance Bldg., Chicago, Ill.

GIFFORD, STANLEY, E.M. 1889
Sec. and Treas. of the United Copper Co., 42 Broadway, N. Y. City.

GILDERSLEEVE, ALGER C., C.E. 1890
Consulting Engineer, 143 Liberty St., N. Y. City.

GILL, A. W., C.E. 1897
26 Prospect St., Northampton, Mass.

GILLETT, H. P., E.M. 1892
Park Row Bldg., N. Y. City.

GILLETTE, LOUIS A., PH.B., MECH.E. 1902
Fishkill-on-Hudson, N. Y.

GILLIES, WILLIAM F., MECH.E. 1904
Montclair, N. J.

GODLEY, R. D., JR., E.E. 1896
Whitestone, L. I.

GODWIN, HERBERT, B.S. (ARCH.) 1902
125 West 122d St., N. Y. City.

GOEPEL, CARL PAUL, E.E., LL.B. 1902
Attorney-at-Law and Patent Counsel, 290 Broadway, N. Y. City.

GOERWITZ, WILLIAM, E.E. 1901
190 Third Ave., N. Y. City.

GOETZE, FREDERICK A., M.Sc. 1895
Dean, Faculty of Applied Science, and Consulting Engineer, Columbia Univ.

GOING, CHARLES BUXTON, PH.B. (CHEM.) 1882
Managing Editor, *The Engineering Magazine*, N. Y. City.

GOLDBAUM, LOUIS, E.E. 1907

GOLDBERG, HERMAN, C.E. 1904
116 Stanton St., N. Y. City.

GOLDBERG, SAMUEL, E.E. 1906
136 Cook St., Brooklyn, N. Y. City.

GOLDEN, PERCY MORRIS, E.E. 1902
72 West Grand St., Elizabeth, N. J.

GOLDMAN, M. G., E.M. 1905
U. S. Geol. Survey, Washington, D. C.

GOLDSCHMIDT, SAMUEL ANTHONY, A.B., A.M., E.M., PH.D. (CHEM.) . 1871
President Columbia Chemical Works, 43 Sedgwick St., Brooklyn, N. Y. City.

GOLDSMITH, BYRON BENJAMIN, PH.B. (CHEM.) 1887
19 East 74th St., N. Y. City.

GOLDSMITH, GODWIN, PH.B. 1896
111 Fifth Ave., N. Y. City.

GOOD, GEORGE MCCLELLAN HOUTZ, E.M. 1886
Supt. Coal Mining Companies, Osceola Mills, Pa.

GOODE, EDMUND L., E.M. 1901
Care Atlantic and Cairo Const. Co., 111 Broadway, N. Y. City.

GOODELL, GEORGE A., A.M. 1898
59th St. and Tenth Ave., N. Y. City.

GOODMAN, J., C.E. 1898
157 West 111th St., N. Y. City.

GOODMAN, LOUIS, C.E. 1903
With Bridge Dept., N. Y. City.

GOODMAN, MAURICE, B.S., E.M. 1901
333 East 4th St., N. Y. City.

GOODRICH, JOHN S., MECH.E. 1904
26 Commerce St., Rahway, N. J.

GOODRIDGE, J. W., C.E. 1897
981 Greene Ave., Brooklyn, N. Y. City.

Goodwillie, Robert Hogue, E.E. 1900
111 Bruce Ave., Yonkers, N. Y.

Goodwin, Edward, E.M. 1891
Zangraft Mine, New Castle, California.

Goodwin, H. Harrison, C.E. 1906
Asst. Eng. New York Board of Water Supply.

Gordon, John, E.M. 1871
22 South Audley St., London, England.

Gorren, Daniel, C.E. 1907
429 West 117th St., N. Y. City.

Gotthelf, A. H., B.S. (Ph.D., 1900) 1897
Chemist to the Revision Committee of the U. S. Pharmacopœia, Hastings-on-Hudson, N. Y.

Gottsberger, B. B., B.S. (Arch.), C.E. 1895
Copperhill, Tenn.

Gottschall, L. 1898
207 East 53d St., N. Y. City.

Gould, Edwin (Associate) 1898
195 Broadway, N. Y. City.

Grace, F. J. M., C.E 1895
With W. R. Grace & Co., San Francisco, Cal.

Graff, Charles Everitt, E.M. 1885
Supt. Standard Oil Co., Eagle Works, New Jersey.

Granger, A. D., C.E. 1892
Pres. Oswego Boiler and Engine Co., West St. Building, N. Y. City.

Grant, Harry Allen, Mech.E. 1904
Adv. Mgr. Maxwell Briscoe Motor Co., Tarrytown, N. Y.

Grant, Oliver Remick, E.E. 1902
Asst. Electrical Engineer The Safety Insulated Wire and Cable Co., N. Y. City.

Gratacap, Louis Pope, Ph.B. (Chem.), A.M. 1876
Curator American Museum Natural History, N. Y. City.

Gray, Clifford, E.E. 1902
P. G. Student in Civil Engineering Columbia University.

Greenbaum, Leo. S., Mech.E. 1901
115 East 71st St., N. Y. City.

Greene, David Joy, C.E., M.E. (Sibley Coll.) 1894
Pres. Empire Wood Co., Jersey City, N. J.

Greene, Russell de C., C.E. 1906
500 West 112th St., N. Y. City.

Greene, Wilkins Updyke, Ph.B. 1880
Fabers, Nelson Co., Va.

Greenleaf, James Leal, C.E. 1880
Landscape Architect, 1 Broadway, N. Y. City.

Gregory, L. E., C.E. 1893
U. S. Navy Yard, Norfolk, Va.

Greiff, Victor R., E.E. 1907
166 West 79th St., N. Y. City.

Grevatt, Frank F., E.E. 1903
With Crocker-Wheeler Co., Ampere, N. J.

Griffen, S. P., Jr. 1884
Litchfield, Conn.

Griffith, P. LeR., E.E. 1903
18 Cortland St., N. Y. City.

Griffith, Vincent Colyer, Ph.B. (Arch.) 1889
160 Herkimer St., Brooklyn, N. Y. City.

Griggs, Wilfred Elizur, Ph.B. (Arch.) 1889
Waterbury, Conn.

Griswold, Clyde T., B.A., E.M. 1905
Mine Supt. at Crean Hill for Canadian Copper Co., Ontario.

Griswold, William T., C.E. 1881
U. S. Geological Survey, Washington, D. C.

Gross, Louis Nathan, B.S., E.M. 1884
Merchant, 38 East 58th St., N. Y. City.

Gudeman, Edward, Ph.B. (Chem.), Ph.D. 1887
Consulting Chemist and Chemical Engineer, Food and Technical Expert, 903-904 Postal Telegraph Bldg., Chicago, Ill.

Gudewill, Charles Edward, C.E. 1890
Montreal Pipe Foundry, Ltd., Montreal, Canada.

Guiterman, Edward Wolf, Ph.B. (Chem.) 1889
Supt. Passaic Print Works, Passaic, N. J.

Gumaer, A. H., B.S. (Arch.) 1898
292 Pavonia Ave., Jersey City, N. J.

Gunn, G. B., C.E. 1898

Gunther, C. Godfrey, E.M. 1903
Clifton, Ariz., and 1735 Cropsey Ave., Brooklyn, N. Y. City.

Haas, Edward F., B.S., C.E. 1894
Sanitary Engineer, San Francisco, Cal.

Haas, H. C., E.E. 1905
Inspector in Operating Dept., Electric Storage Battery Co., N. Y. City.

Haas, Harry Leopold, Ph.B. 1878
526-530 West 25th St., N. Y. City.

Haasis, Dunbar Ferdinand, E.M. 1883
Engineer, Improvement of harbor bars on Atlantic and Gulf coasts, 45 Gordon St., Perth Amboy, N. J.

Hadden, Howard S., B.S. (Arch.), Ph.B. 1895
136 Willow St., Brooklyn, N. Y. City.

Haffen, Louis Francis, A.M., C.E., LL.D. 1879
President of the Borough of the Bronx, N. Y. City.

Hahn, Albert W. (Chem.) 1905
Chemist for O. Y. T. Braniff at Maconi Cadereyta, Querétaro, Mexico.

Hahnel, A. F., E.M. 1905
Tahuahuito el Alto, Durango, Mexico.

Haight, Clarence M., E.M. 1906
Adventure Consolidated Copper Co., and Michigan Copper Mining Co., Rockland, Michigan.

Haight, C. S., B.S. (Arch.) 1898
U. S. War Dept., Washington, D. C.

Haight, Louis H., E.E. 1904
Westinghouse Elect. and Mfg. Co., N. Y. City.

Haines, E. J., E.E. 1905
878 St. John's Place, Brooklyn, N. Y. City.

Haines, Harold W., B.S. (Chem.) 1903
Physics Dept., High School of Commerce, N. Y. City.

Haldy, George F., E.E. 1897
Stamford, Conn.

Hall, H., B.S. (Arch.) 1899
204 Hancock St., Brooklyn, N. Y. City.

Hall, Robert William, E.M. 1876
Professor of Analytical Chemistry, N. Y. University.

Hallock, Albert Peter, Ph.B. (Chem.), Ph.D. 1880
Chemist to Carl H. Schultz, Min'l Water Factory, 440 First Ave., N. Y. City.

Halpin, Zacharia P., E.E. 1907
506 West 143d St., N. Y. City.

Hamilton, Frank C., E.M., A.M. 1894
Chief Chemist, Compañia Minera de Peñoles, Mapimi, Durango, Mexico.

Hamilton, Schuyler, Jr., A.B., A.M., E.M. 1876
Croton-on-Hudson, Westchester Co., N. Y.

Hammerschlag, Henry A., B.S. (Chem.) 1907
38 Breintnall Place, Newark, N. J.

Hanau, H. S., C.E. 1904
107 West 126th St., N. Y. City.

Haneman, John T., B.S. (Arch.) 1902
170 West 59th St., N. Y. City.

Hankinson, Albert Worthington 1893
62 West 85th St., N. Y. City.

Harding, George Edward (Associate) 1867
Architect and Civil Engineer, 253 Broadway, N. Y. City.

Harker, Charles Sumner, E.M. 1879
65 Union St., San Francisco, Cal.

Harmer, Thomas Hayes, A.B., A.M., E.M. 1867
256 West 85th St., N. Y. City.

Harmon, Arthur L., B.S. (Arch.) 1902
Care McKim, Mead & White, 160 Fifth Ave., N. Y. City.

Harrington, Thomas Henry, C.E. 1889
Tutor in Drawing, Columbia University, N. Y. City.

Harris, E. A., Ph.B. (Chem.) 1889
158 Perry St., N. Y. City.

Harrison, Newton, E.E. 1892
358 East 50th St., N. Y. City.

Hart, Charles H., C.E. 1900
199 Lenox Ave., N. Y. City.

Harte, Charles Rufus, C.E. 1893
Asst. Engr., N. Y., N. H. & H. R. R., Naugatuck Div., 165 York St., New Haven, Conn.

Harwood, Paul H., E.M. 1903
Asst. Mgr. and Eng., Mexican Asphalt Paving and Con. Co., Mexico, D. F.

Hasegawa, Yothinosuke, E.M., Ph.D. 1878
Nippon Kogiokai, No. 15, Kagacho, Kiobashiku, Tokio, Japan.

Haskell, G. M., E.E. 1898
Sales Dept. of the Safety Insulated Wire and Cable Co., N. Y. City.

Haskell, Harry Garner, E.M. 1893
Sec. Repanno Chemical Co. and Hercules Powder Co., Wilmington, Del.

Hastings, Charles F., C.E. 1902
15 West 50th St., N. Y. City.

Hatch, Walter Percy, Jr., Mech.E. 1902
Asst. Mgr. Continental Car and Equipment Co., N. Y. City.

Hathaway, Nathaniel, Ph.B. (Chem.) 1879
Teacher of Chemistry and Physics, Swain Free School, New Bedford, Mass.

Haviland, Henry Field, E.E. 1902
With Francis Bros. & Jellet, Inc., N. Y. City.

Havill, Owen A., A.B., E.E. 1901
Asst. in office of Viele, Cooper & Blackwell, Consulting Engineers, N. Y. City.

Hawkes, Emil McDougal, A.B., E.M. 1885
42 East 26th St., N. Y. City.

Hawkesworth, John, C.E. 1904
Asst. Engr. with R. F. Almirall, Architect, N. Y. City.

Hawkins, S. O., B.S. (Arch.) 1899
61 Lefferts Place, Brooklyn, N. Y. City.

Hawks, H. D., E.E. 1896
Tarrytown, N. Y.

Hawley, John Francis, E.E. 1891
Guatemala City, Central America.

Hay, Arthur, E.M. 1892
Sec.-Engr. of Pleasure Driveway and Park District of Springfield, Ill.

Hebert, Octave Britton, C.E. 1888
Sec.-Treas. Aitken Construction Co., N. Y. City.

Heidgerd, Gustav H., A.B., E.E. 1907
142 West 122d St., N. Y. City.

Heike, R. E., B.S. (Chem.) 1899
P. O. Box L, Jersey City, N. J.

Heinekin, William Price, E.E. 1900
New Brighton, S. I.

Heinsheimer, Alfred Maurice, C.E. 1887
Traitel Bros. & Co., 133 West 42d St., N. Y. City.

Heinze, Frederick Augustus, E.M. 1889
31 Nassau St., N. Y. City.

Heller, Clarence, C.E. 1904
Heller & Wilson, Consulting Engineers, San Francisco, Cal.

Henderson, H. H., C.E. 1899
87 Locust Hill Ave., Yonkers, N. Y.

Hendrickson, William H., E.M. 1903
Engineer Gemini and Godiva Mining Co., Eureka, Utah.

Henes, Louis George, Mech.E. 1903
Mgr. Machine Tool Dept. of Harron, Rickard & McCone, San Francisco, Cal.

Henne, Christopher, 2d, E.M. 1900
Los Angeles, Cal.

Herckenrath, W. A., E.M., C.E. 1892
1690 Morris Ave., Bronx, N. Y. City.

Herz, Henry, Ph.B. (Arch.) 1897
142 Mercer St., Jersey City, N. J.

Herzig, C. S., E.M. 1895
With Beckwith, Moreing & Co., London, England.

Hess, Edward, Met.E. 1906
340 East 20th St., N. Y. City.

Hesselbach, Charles V., C.E. 1896
111 East 31st St., N. Y. City.

Hewitt, Edward Shepard, B.S. (Arch.) 1901
182 Congress St., Brooklyn, N. Y. City.

Hewlett, James Monroe, Ph.B. 1890
Architect, 16 East 23d St., N. Y. City.

Heye, George G., E.E. 1896
52 Broadway, N. Y. City.

Heyman, William, C.E. 1905
148 Newark Ave., Jersey City, N. J.

Higbie, H. Harold, E.E. 1904
Instructor in Elect. and Mech. Eng., University of Michigan.

Higgins, James Edward, E.M. 1904
413 West 117th St., N. Y. City.

Hildburgh, Walter Leo, E.E., A.M. 1897
St. Ermin's, Westminster, London, England.

Hildreth, Thomas Flager, B.S. (Chem.) 1901
126 Pine St., Lockport, N. Y.

Hildreth, Walter Edwards, C.E., E.M. 1877
Consulting Engineer, The Breslin, Broadway and 29th St., N. Y. City.

Hill, Lawrence, B.S. (Arch.) 1901
Care John Yard, Esq., 66 Broadway, N. Y. City.

Hill, R. F., Jr., E.M. 1898
Care Gen. Chem. Co., 25 Broad St., N. Y. City.

Hill, William, C.E. 1882
Pres. The Collins Co., Collinsville, Conn.

Hinman, Bertrand Chase, Ph.B. (Chem.), A.M. 1890
Director Village Main Reef Gold Mining, Ltd., etc., Heathfield, 48 Sydenham Hill, London, S. E., England.

Hirschthal, Meyer, B.S., C.E. 1902
With Henry Steers, Inc., N. Y. City.

Hitchcock, C. K., Jr., A.B., A.M., E.M. 1900
Chief Engineer, Quincy Mine, Hancock, Mich.

Hochlemer, Tobias, C.E. 1901
Asst. Engr. Croton Aqueduct Com., N. Y. City.

Hochsprung, George W., E.E. 1904
With N. Y. and N. J. Telephone Co., N. Y. City.

Hodgson, E. H., B.S. (Chem.) 1898
848 President St., Brooklyn, N. Y. City.

Hoguet, Ramsay, E.E. 1903
141st St. and Hudson River, N. Y. City.

Holbrook, F. M., E.E. 1897
27 William St., N Y. City.

Holden, Charles A., C.E. 1903
With P., N. Y. & L. I. R. R. Co.

Holden, Edwin C., B.S., E.M. 1896
Consulting Mining Engineer, 25 Broad St., N. Y. City.

Holden, Edward Henry, C.E. 1878
Asst. Engr., Bronx Borough, N. Y. City, in Topographical Bureau.

Hollerith, Herman, E.M., Ph.D. (1890) 1879
Gen. Mgr. The Tabulating Co., 1054 Thirty-first St., Washington, D. C.

Hollick, Arthur, Ph.B. (Geol. and Paleont.), Ph.D. 1879
Curator, Botanical Gardens, N. Y. City.

Hollis, Henry Leonard, E.M. 1885
Consulting Mining Engr. and Metallurgist, First Nat'l Bank Bldg., Chicago, Ill.

Hollis, William, C.E. 1878
Box B, Eagle Pass, Texas.

Hollmann, F. W., Mech.E. 1905
Steam Engr., Maryland Steel Co., Sparrows Point, Md.

Holmes, Duncan A., E.E. 1904
203 West 79th St., N. Y. City.

Holt, Marmaduke Burrell, E.M. 1889
Silverton, Col.

Holter, Norman Bernard, E.M., A.M. 1891
Holter Hardware Co., Helena, Mont.

Hooker, William H., A.B., A.M., E.M. 1869
2 Wall St., N. Y. City.

Hooper, Frank Cyrus, Met.E. 1890
Consulting Engineer, North River, Warren Co., N. Y.

Hooper, George H., Jr., E.E. 1905
With Edison Storage Battery, West Orange, N. J.

Hooper, Louis Mosher, C.E. 1880
Rutherford, N. J.

Hopke, T. M., Ph.B. (Chem.) 1880
Nat. Tube Co., McKeesport, Pa.

Hopkins, George G., A.B., M.E. 1901
Inspector, New York Board of Fire Underwriters, N. Y. City.

Horn, James Thurston, A.B., C.E. 1884
367 Lenox Ave., N. Y. City.

Hornbostel, Henry Frederick, Ph.B. (Arch.) 1891
63 William St., N. Y. City.

Horne, William Dodge, Ph.B. (Chem.), Ph.D. 1886
Chemist to Yonkers Water Works, Yonkers, N. Y.

Horner, R. R., E.M. 1900
Johannesburg, South Africa.

Hosford, Leonard P., C.E. 1906
Sec. of Spalding-Hosford Co., Inc., N. Y. City.

How, R. W., Jr., C.E. 1898
44 Court St., Brooklyn, N. Y. City.

Howe, Epenetus, E.M. 1886
Gen'l Assay and Mining Business and Consulting Engr., Monterey, Mexico.

Howell, John Jacob, Mech.E. 1904
With A. B. See Electric Elevator Co., N. Y. City.

Hoyt, John R., E.M. 1906
Mine Examinations in Canada and West.

Hoyt, John Sherman, C.E. 1890
1 Broadway, N. Y. City.

Hoyt, R., C.E. 1893
Katonah, N. Y.

Hoyt, W. L., C.E. 1876
Denver, Col.

Hudson, Darwin Shaw, C.E. 1901
157 Franklin St., Astoria, N. Y.

Hudson, Edward Henry, C.E. 1880

Hudson, P. K., E.M. 1899
Junior Partner in firm of C. I. Hudson & Co., N. Y. City.

Hulbert, Charles S., E.E 1899

Hulbert, William R., Mech.E. 1904
Sec. of the Knobbe Co. and Managing Editor of *Compressed Air*, N. Y. City.

Humbert, W. S., E.M. 1883
Niagara Falls, N. Y.

Hume, F. T. 1893
82 East 79th St., N. Y. City.

Humphrey, F. L., C.E. 1905
U. S. Reclamation Survey. Selden, New Mexico.

Hunt, Frederick Furneaux, E.M., C.E. 1876
77 Pine St., N. Y. City.

Huntington, C. 1869
Flushing, L. I., N. Y. City.

Huntington, F. W., E.M. 1885
Teacher of Physics, Erasmus Hall High School, Brooklyn, N. Y. City.

HUNTINGTON, W. CHAPIN, MECH.E. 1907
Care National Laboratory, National Tube Co., McKeesport, Pa.

HUNTOON, L. D., E.M., PH.G. 1895
Asst. Prof. Mining and Metallurgy, Sheffield Scientific School, Yale Univ.

HUNTTING, HENRY OGDEN, PH.B. (CHEM.) 1887
260 St. James Place, Brooklyn, N. Y. City.

HURLBERT, E. D., JR., C.E. 1890
Riverside, Conn.

HUTCHINS, G. L., E.M. 1898
522 Dooley Block, Salt Lake City, Utah.

HUTTON, FREDERICK REMSEN, A.B., A.M., E.M., C.E., PH.D. . . . 1876
Pres. American Society Mechanical Engineers, N. Y. City.

HYATT, CHARLES EDWARD, E.E. 1896
936 Broad St., Newark, N. J.

HYDE, FREDERICK S., PH.B. (CHEM.) 1893
With Dr. H. N. Potter, N. Y. City.

HYDE, HENRY ST. JOHN, B.S. (CHEM.), PH.B., A.M. 1896
Candidate for Ph.D. in School of Pure Science, Columbia University.

HYMAN, WALLACE MUNROE, E.E. 1902
In office of P. R. Moses, E.E., 320 Fifth Ave., N. Y. City.

IHLSENG, A. O., B.S., E.M., C.E. 1877
45 Broadway, N. Y. City.

IHLSENG, M. C., C.E., E.M., PH.D. (CHEM.) 1875
Prof. of Mech. Eng., Polytechnic Inst. of Brooklyn, N. Y. City, and Expert Engineering Examiner, M. C. S. C., N. Y. City.

ILES, MALVERN WELLS, PH.B. (CHEM.) 1875
Ilsmere, The Palms, Cal.

IMMEDIATO, GERARDO, MECH.E., C.E. 1901
Asst. Eng., Monterey Water Works, Monterey, Mexico.

INGRAM, EDWARD LOVERING, C.E. 1885
Asst. Prof. Civil Eng., University of Pennsylvania.

IRVINE, FREDERICK BRICE, C.E. 1902
Consulting Engineer, 25 Broad St., N. Y. City.

IRVING, JOHN DUER, A.M., PH.D. 1899
Prof. of Economic Geology, Sheffield Scientific School, Yale University.

IVES, ARTHUR STANLEY, C.E., E.E. 1889
Care Glamorgan Pipe and Foundry Co., Lynchburg, Va.

JACKSON, CHARLES EDWARD, C.E. 1875
15 Cortland St., N. Y. City.

JACKSON, OSWALD, C.E. 1892
Engineer-Inspector, Dept. Public Works, Dept. Highways, N. Y. City.

JACOBS, DAVID MARK, PH.B. (CHEM.) 1887
R. J. Jacobs & Co., 41 New St., N. Y. City.

JACOBS, H. A., PH.B. (ARCH.) 1894
107 East 78th St., N. Y. City.

JACOBS, SOLOMON JOSEPH, PH.B. (CHEM.) 1887
R. J. Jacobs & Co., 41 New St., N. Y. City.

JACOBSON, SAMUEL O., E.E. 1905

JACOBY, HENRY E., MECH.E. 1903
Manager, Marcus Mason & Co., N. Y. City.

JAMES, M. T., PH.B. (ARCH.) 1900
1261 Madison Ave., N. Y. City.

JANES, E. H., PH.B. (ARCH.) 1895
925 West End Ave., N. Y. City.

JANEWAY, JOHN HOWELL, JR., E.M. 1886
Gen. Mgr. Mineral Point Zinc Co., Chicago, Ill.

JARCHO, ISAIAH, E.E. 1904
With N. Y. C. & H. R. R. R. Co., N. Y. City.

JARMAN, Z. H., E.M. 1895
112 Lefferts Place, Brooklyn, N. Y. City.

JARMULOWSKI, MEYER, PH.B. (ARCH.) 1890
173 East Broadway, N. Y. City.

JARVIS, ROYAL P., E.M. (GOLDEN), A.M. 1907
University of Tennessee, Knoxville, Tenn.

Jenks, Arthur Wilton, E.M. 1886
Mine Examination Work, Room 606, Alaska Bldg., Seattle, Wash.

Jenny, Walter Proctor, E.M., Ph.D. 1869
Consulting Engineer, Salt Lake City, Utah.

Jessup, Warren Canfield, E.E. 1900
120 Liberty St., N. Y. City.

Jeup, B. J. F., C.E. 1887
121 Highland Ave., Indianapolis, Ind.

Joachum, Henry L., C.E. 1905
465 East 57th St., N. Y. City.

Jobbins, F. H., Ph.B. (Chem.) 1895
Sec. and Treas. Wm. F. Jobbins, Inc., Aurora, Ill.

Jocoby, George Washington, B.S. (Arch.) 1902
112 East 70th St., N. Y. City.

Joffe, Meyer, C.E. 1894
158 Henry St., N. Y. City.

Johnson, Arthur Gale, E.M. 1885
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y. City.

Johnson, Arthur Michael, E.M. 1906
Mine Survey with New Jersey Zinc Co., Franklin Furnace, N. J.

Johnson, Elias Mattison, Ph.B. 1878
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y. City.

Johnson, Gilbert Henry, Ph.B. (Chem.) 1878
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y. City.

Johnson, H. Norton, E.M. 1906
Amalgamated Copper Co., Butte, Mont.

Johnson, Isaac Bradley, E.M. 1879
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y. City.

Johnson, Robert McL., E.M. 1906
Asst. Engr., Spanish-American Iron Co., Daiquiri, Cuba.

Johnstone, William Baird, C.E. 1895
Asst., P., N. Y. & L. I. R. R.

Jones, J. E. 1898
519 Pelham Road, New Rochelle, N. Y.

Jones, J. Elmer, E.M. 1893
Supt. Mill Creek Coal Co., New Boston, Pa.

Jones, Russell C., Mech.E. 1907
100 West 76th St., N. Y. City.

Jones, Richard M., E.M. 1905
935 Kirkpatrick Ave., Allegheny, Pa.

Jones, Thomas Jefferson, Met.E. 1890
Iron Mountain, Keswick, Cal.

Jones, William D., Ph.B. (Chem.) 1888
Short Hills, N. J.

Jones, W. P., E.E. 1898
18 Garden Place, Brooklyn, N. Y. City.

Jopling, Reginald Furness, E.M. 1889
Jopling & Escobar, Engineers, Cleveland, O.

Jordao, Joseph Nabor Pacheco, C.E., E.M., Ph.B. 1877
Paulista Ry., San Paulo, Brazil.

Joseph, Theodore H., E.E. 1898
With E. J. Electric Installation Co., Contracting Engineers, New York.

Joesphi, Robert, E.E. 1906
Chemical Imp. and Mfg. Co., 90 West St., N. Y. City.

Josephs, Irving S., A.B. (Coll., 1905), E.M. 1907
2880 Broadway, N. Y. City.

Josephson, Edgar, B.S. (Chem.) 1900
Chemist for the Pantasote Leather Co., Passaic, N. J.

Jouet, Cavalier Hargrave, Ph.B. (Chem.), Ph.D. 1882
Tutor in Analytical Chemistry, Columbia University, N. Y. City.

Judd, Charles Breck, E.M. 1881
1211 Park Building, Pittsburgh, Pa.

Judd, Edward K., E.M. 1904
522 West 123d St., N. Y. City.

Judson, Hanford Chase, E.E. 1898
With General Electric Co., as Engineer, N. Y. City.

Julihn, Carl Edward, E.M. 1904
Mining work in Northwest, Helena, Mont.

Jung, A. N., E.E. 1899
Los Angeles, Cal.

Kafka, Hugh, Jr., B.S. (Arch.) 1901
617 West 138th St., N. Y. City.

Kaiser, Charles Sumner, B.S. (Arch.) 1902
160 Fifth Ave., N. Y. City.

Kanolt, Clarence Whitney, B.S. (Chem.) 1902
Western Reserve University, Cleveland, Ohio.

Kaplan, Harry, B.S., M.E., A.M. 1906
Asst. Eng., Struct. Mats., Test. Lab., U. S. Geol. Survey, St. Louis, Mo.

Karr, C. P., Ph.B. (Geol.) 1878
70 Fifth Ave., N. Y. City.

Kaufman, Alfonse, E.E. 1906
Westinghouse Elect. and Mfg. Co., Pittsburgh, Pa.

Kaufmann, Arthur, B.S. (Arch.) 1900
11 East 66th St., N. Y. City.

Kaufmann, Edwin, Ph.B. (Arch.) 1897
32 East 23d St., N. Y. City.

Kayser, William D., Mech.E. 1903
Brooklyn Heights R. R. Co.

Keeler, Frederick Sterling, Ph.B. (Arch.) 1891
131 West 116th St., N. Y. City.

Kellogg, J. Blake, M.E. 1904
910 Union Trust Co. Bldg., San Francisco, Cal.

Kellogg, L. O., E.M. 1906
Eng., American Rincon Mining Co., Temasealtepec, Est. de Mexico, Mexico.

Kelly, William, A.B., E.M. 1877
Vulcan, Dickinson Co., Mich.

Kemp, James Furman, A.B., E.M. 1884
Professor of Geology, Columbia University, N. Y. City.

Kempner, Milton, A.B., C.E. 1901
191 Monroe St., N. Y. City.

Keppell, David, B.S. (Arch.) 1902

Kern, Edward F., B.S., Ph.D. 1901
Tutor in Metallurgy, Columbia University, N. Y. City.

Kidder, Sidney J., E.M. 1904
De Lamar, Nevada.

Kilbourne, Covington G., E.E. 1906
272 Manhattan Ave., N. Y. City.

Kilian, Theodore P., C.E. 1906
421 West 144th St., N. Y. City.

Kilian, William G., Ph.B. 1897
9 Maiden Lane, N. Y. City.

King, Charles A., M.E. 1906
With Henry C. Meyer, Jr., Consulting Engineer, N. Y. City.

King, Harold F., E.M. 1907
61 Maiden Lane, Kingston, N. Y.

Kinsey, Frank Wilmarth, C.E. 1891
Supt. Morris & Cummings Dredging Co., N. Y. City.

Kipp, Burdett, C.E. 1898
Rapid Transit R. R. Com., N. Y. City.

Kirby, G. T., E.E., LL.B. 1895
Lawyer, 2 Wall St., N. Y. City.

Kissam, Henry Snyder, Ph.B. 1886
Architect, 156 Fifth Ave. and University Club, N. Y. City.

Klaber, William, Ph.D. (Chem.) 1907
628 West 114th St., N. Y. City.

Klepetko, Frank, E.M. 1880
Consulting Engineer, 1311 West St. Bldg., N. Y. City.

Kletchka, John Joseph, A.B., C.E. 1892
272 Clinton St., Brooklyn, N. Y. City.

Knapp, John Augustus, A.B., A.M., E.M. 1870
11-13 William St., N. Y. City.

Kneeland, F. R., B.S. (Chem.) 1899
Technology Club, Boston, Mass.

Kniffen, Lloyd M., E.M. 1906
Cyanide Supt., Dolores Mines Co., Mexico.

Knight, Harold Bartlett, B.S. (Arch.) 1901
103 West 69th St., N. Y. City.

Knoblauch, George W., E.M. 1903
Central Chili Copper Co., Panulcillo, Coquimbo, Chili.

Knox, Charles E., E.E. 1892
Special Partner of C. Q. Mailloux, 76 William St., N. Y. City.

Knox, N. B., A.B., E.M. 1897
310 Pine St., San Francisco, Cal.

Koch, Richard, E.E. 1897
270 West 115th St., N. Y. City.

Koen, J. J., C.E. 1888
160 Prospect Park West, Brooklyn, N. Y. City.

Kohler, L. Frank, E.E. 1905
Inspector Electrical Dept., N. Y. C. & H. R. R. R.

Kohn, Robert David, Ph.B. (Arch.) 1890
96 Fifth Ave., N. Y. City.

Kohnstamm, Lothair S., B.S. (Chem.) 1902
Chemist and Asst. Supt., Atlas Color Factory, Brooklyn, N. Y. City.

Kong, Shun Tet, A.M. 1907
Livingston Hall, Columbia University.

Korn, Lewis, Ph.B. (Arch.) 1890
Architect, Fifth Ave., N. Y. City.

Koscherak, Ferdinand Eli, E.E. 1900
127 West 82d St., N. Y. City.

Kraemer, Henry, Ph.B. (Chem.) 1895
Consulting Chemist, 424 South 44th St., Philadelphia, Pa.

Kraut, Max, E.M. 1905
57 Warren St., N. Y. City.

Kress, Otto, B.S. (Chem.) 1906
438 West 116th St., N. Y. City.

Kretz, Walter C., Ph.D., Mech.E. 1902
133 West 129th St., N. Y. City.

Kreuder, Herman Ernst, A.B., E.E. 1907

Kropff, Alfred H., B.S. (Chem.) 1907
136 West 119th St., N. Y. City.

Kruse, Frederick, Jr., E.M. 1907
Central City, Col.

Kunhardt, Wheaton Bradish, E.M. 1880
Treas. and Gen. Mgr., The Carpenter Steel Co., Reading, Pa.

Kurtz, Edward Laurence, E.M. 1893
Instructor in Mining, Columbia University.

Lacombe, Charles Frederick, E.M. 1885
Chief Eng. of Surface Con., Dept. Water Supply, Gas and Elec., N. Y. City.

Ladew, J. Harvey (Associate) 1885
300 Central Park West, N. Y. City.

Lage, Frederico, Met.E. 1907
Rio Janeiro, Brazil.

Lahey, Joseph, E.M. 1887
59 East 65th St., N. Y. City.

Lahey, Richard, E.M. 1887
With Mason & Hoge Co., N. Y. City.

Lamb, Andrew Johnson, E.M. 1884
Roadmaster, L. & N. R. R., Birmingham, Ala.

Lamme, Maurice A., B.S., A.M. 1904
Asst. in Mineralogy, Columbia University, N. Y. City.

Landers, Marsden H., E.M. 1906
921 Greene Ave., Brooklyn, N. Y. City.

Landers, William H., E.M. 1903
Asst. Sec. Nevada Assn. of San Francisco, Cal.

LANE, RUSSELL, B.S. (ARCH.) 1897
325 Lincoln Ave., Orange, N. J.

LANG, EUGENE JEROME, B.S. (ARCH.) 1900
433 Broadway, N. Y. City.

LANGMUIR, A. C., PH.B. (CHEM.) 1893

LANGMUIR, IRVING, MET.E. 1903
Instructor in Engineering Chemistry at Stevens Institute, Hoboken, N. J.

LANGTHORN, JACOB S. (ASSOCIATE) 1891
Division Engineer, Board of Water Supply, N. Y. City.

LAUGHLIN, W. C., E.M. 1899
Operating Chipioni Cons. Mines, Sonora, Mex.

LAW, CHARLES T., E.M. 1903
Chief Engineer, Deep Gravel Mining Co., Kougarok, Alaska.

LAWRENCE, AUGUSTINE NEIL, E.E. 1901
918 Arch St., Philadelphia, Pa.

LAWRENCE, BENJAMIN BOWDEN, E.M. 1878
Consulting Mining Engineer, 60 Wall St., N. Y. City.

LAWRIE, HAROLD, E.M. 1905
Prospecting the South Umpqua River, Perdue, Oregon.

LAZINSK, ABRAHAM, A.B., C.E. 1905
236 West 136th St., N. Y. City.

LEARY, DANIEL JAMES, C.E., E.M. 1881
Engineer and Contractor, Bridges, Docks and Harbor Improvements, 26 West 49th St., N. Y. City.

LEARY, GEORGE, C.E. 1891
Pres. Morris & Cummings Dredging Co., 17 State St., N. Y. City.

LEAVENS, H. W., E.M. 1875
Broken Hill Refinery Co., Port Pirie, Australia.

LEBOUTILLIER, CLEMENT, PH.B. (CHEM.) 1881
Chemist and Metallurgist, Taylor Iron and Steel Co., High Bridge, N. J.

LEBOWITZ, WILLIAM, E.E. 1906
1479 Washington Ave., N. Y. City.

LEDERLE, ERNEST JOSEPH, PH.B. (CHEM.), PH.D. 1886
Consulting Chemist, 471 West 143d St., N. Y. City.

LEDOUX, ALBERT REID, M.S., PH.D. (ASSOCIATE) 1874
Consulting Engineer and Chemist, 99 John St., N. Y. City.

LEDOUX, AUGUSTUS DAMON, PH.B. (CHEM.) 1881
68 Beaver St., N. Y. City.

LEE, GEORGE BARSTOW, E.M. 1885
Supt. Copper Queen Reduction Works, Douglas, Arizona.

LEE, HENRY CHARLES, C.E. 1886
Hotel Irving, 26 Gramercy Park, N. Y. City.

LEEMING, THOMAS LONSDALE, PH.B. (CHEM.) 1894
73 Warren St., N. Y. City.

LEGGETT, THOMAS HAIGHT, E.M. 1879
Consulting Mining Engineer, Mills Bldg., 15 Broad St., N. Y. City.

LENOX, LIONEL REMOND, PH.B. (CHEM.) 1888
Prof. of Analytical Chemistry, Leland Stanford, Jr., Univ., Palo Alto, Cal.

LE PRINCE, JOSEPH A., C.E., A.M. 1898
Ancon, Canal Zone, Panama.

LEO, R. L., PH.B. (ARCH.) 1895
285 Broadway, N. Y. City.

LEVIN, HERTZ, E.E. 1907
178 Second Ave., N. Y. City.

LEVINE, ALBERT JULIUS, E.E. 1901
3337 West 88th St., N. Y. City.

LEVINE, EDMUND J., B.S. (CHEM.) 1898
The Fiberloid Co., 636 Broadway, N. Y. City.

LEVITT, BORIS A., C.E. 1903
Asst. Engr., Board of Water Supply, N. Y. City.

LEVY, A. L., E.M. 1890
149 Franklin St., N. Y. City.

LEWINSON, LEONARD JULIAN, E.E. 1904
Electrical Testing Laboratories, N. Y. City.

LEWIS, CLARENCE MCKENZIE, C.E. 1898
William Salomon & Co., 25 Broad St., N. Y. City.

LEWIS, MEYER H., C.E. 1900
Leveler on the New Croton Dam, Croton-on-Hudson, N. Y.

LEWISOHN, JULIUS A., A.B., E.M. 1907
42 Broadway, N. Y. City.

LIBAIRE, EDWARD WILLIAM, C.E. 1894
512 West 151st St., N. Y. City.

LICHTENBERG, J. CHESTER, A.A., E.E. 1906
Asst. to M. I. Pupin, Columbia University, N. Y. City.

LICHTENSTEIN, EDWARD GARVAISE, PH.B. (ARCH.) 1890
14 West 74th St., N. Y. City.

LICHTENSTEIN, HOWARD, E.E. 1898
14 West 74th St., N. Y. City.

LIDGERWOOD, JOHN H., JR., M.E., E.M. 1901
With Lidgerwood Mfg. Co., N. Y. City.

LIEBMANN, ALFRED, C.E. 1893
Brewer, N. Y. City.

LIGHTHIPE, WILLIAM WILSON, E.E. 1898
Engineer, Sales Dept. of Otis Elevator Co., N. Y. City.

LILLARD, OGDEN WHITTIER, E.E. 1903
Eng. for Pacific Coast Gould Storage Battery Co., 705 Monadnock Bldg., San Francisco, Cal.

LILLIE, SAMUEL MORRIS, E.M. 1874
Pres. of The Sugar Apparatus Mfg. Co., 328 Chestnut St., Philadelphia, Pa.

LILLIENDAHL, ALFRED WHIPPLE, E.M. 1883
Pres. and Gen. Mgr. The Saltillo Elec. Light and Power Co., and Mexican Electric Power Co., Saltillo, Coahuila, Mexico.

LILLIENDAHL, FRANK ARMSTRONG, E.M. 1891
Traffic Manager, Coahuila and Pacific Road, Saltillo, Mexico.

LINDEMAN, MAURICE, B.S. (CHEM.) 1903
Metallurgist for Bamberger De Lamar Gold Mines Co., De Lamar, Nevada.

LINDENMEYER, LUDWIG, B.S. (ARCH.) 1900
260 West 91st St., N. Y. City.

LINDO, ALBERT, C.E. 1907
Canal Zone, Panama.

LINDSAY, WILLIAM GODSON, B.S. (CHEM.) 1901
Chemist for Ricketts & Banks, N. Y. City.

LINDSLEY, STEWART, E.M. 1870
Orange, N. J.

LIPPS, HENRY, JR., C.E. 1888
Contracting Engineer, 115 Elliott Ave., Williamsbridge, N. Y. City.

LISMAN, OLIVER C., C.E. 1907
165 Park Ave., Mt. Vernon, N. Y.

LITCHFIELD, R. B., E.E. 1906
203 Clinton St., Brooklyn, N. Y. City.

LITTLE, JAMES M., E.M. 1907
Towanda, Pa.

LITTLE, W. B., E.M., PH.B. 1881
5 West 31st St., N. Y. City.

LIVINGSTON, ARCHIBALD ROGERS, C.E. 1891
With Empire Zinc Co., Canon City, Col.

LIVINGSTON, GOODHUE, PH.B. (ARCH.) 1892
10 West 37th St., N. Y. City.

LIVINGSTON, J., JR., E.E. 1898
113 East 22d St., N. Y. City.

LOBO, G., E.E. 1898
P. O. Box 830, Cardena 2, Mexico City, Mexico.

LOCKWOOD, LYNN GROVER, B.S. (ARCH.) 1900
Caldwell, Essex Co., N. J.

LODER, ELWOOD H., C.E. 1903
Asst. Engr., Tompkins Engineering and Construction Co., N. Y. City.

LOEWENTHAL, MAX, E.E. 1897
Consult'g Engr., Pres. Internat'l Elec. Eng. Co., 150 Nassau St., N. Y. City.

LONEY, FREDERICK ROOSEVELT, B.S. (ARCH.) 1901
65 East 64th St., N. Y. City.

Longacre, L. B. 1892
Spuyten Duyvil, N. Y.

Lord, Frederick Reuben, C.E. 1892
F. R. Lord & Co., Steamship Agents and Ship Brokers, N. Y. City.

Lord, Nathaniel Wright, E.M. 1876
338 West Eighth Ave., Columbus, Ohio.

Love, Edward Gurley, A.M., Ph.B. (Chem.), Ph.D. 1876
Analytical and Consult'g Chemist, Chief Gas Exam'r, 122 Bowery, N. Y. City.

Lovejoy, Frederick W., Jr., E.M. 1904
101 Gates Ave., Brooklyn, N. Y. City.

Loveman, Herbert S., M.E. 1905
With Henry R. Worthington, Hydraulic Works, Newark, N. J.

Lowenburg, L., Ph.B., E.E. 1898
2229 Park Ave., Cincinnati, Ohio.

Lowenstein, Joseph, B.S. (Chem.) 1896
Fort Morgan, Col.

Lowndes, William Shepherd, Ph.B. (Arch.) 1890
Elm Ave., Hackensack, N. J.

Lowther, C. M., E.E. 1898
Riverside, Conn.

Lucas, G. L., C.E. 1898
439 Manhattan Ave., N. Y. City.

Lucas, Robert J., C.E. 1905
Topographical Draftsman, Borough of the Bronx, N. Y. City.

Lucke, C. E., B.S., M.S., Ph.D. 1901
Professor Mech. Eng., Columbia University, N. Y. City.

Ludlam, Frank, Ph.B. (Arch.) 1895
804 Aiken Ave., Pittsburgh, Pa.

Ludlam, William K., C.E. 1901
With E. C. Randolph, Bankers and Brokers, 25 Broad St., N. Y. City.

Ludlow, Edwin, E.M. 1879
Gen. Mgr. Mexican Coal and Coke Co. and Coahuila R. R., Las Esperanzas, Coahuila, Mexico.

Lum, C. H., Ph.B. (Arch.) 1895
Chatham, N. J.

Lunt, Horace F., E.M. 1902
Consulting Engineer, Colorado Springs, Col.

Luquer, Lea McIlvaine, C.E., Ph.D. 1887
Adj. Professor of Mineralogy, Columbia University, N. Y. City.

Luquer, Thatcher Taylor Payne, C.E., E.E. 1889
Consulting Engineer, 5 West 31st St., N. Y. City.

Lusk, Graham, Ph.B. (Chem.), Ph.D., M.A., F.R.S. (Edin.) . . . 1887
Prof. of Physiology, N. Y. Univ. and Bellevue Hospital College, N. Y. City.

Luther, Edwin C., C.E. (Princeton, 1902), E.M. 1904
Eng. Dept. Philadelphia and Reading Coal and Iron Co., Pottsville, Pa.

Luttgen, Eberhard, Ph.B. 1884
Ambler, Pa.

Lydecker, Irving Smith, E.M. 1898
Supt. Seaboard Coal and Coke Co., Coal City, Ala.

Lyman, Frank, A.B., E.M. 1878
Treas. The Low Moor Iron Co., Virginia.

Lynn, Henry H. E., C.E. 1907
162 West 96th St., N. Y. City.

Lyon, George John, B.S. (Univ. of Nebraska, 1899), C.E. . . . 1904
Professor of Civil Enginering, Colorado College, Colorado Springs, Col.

McAnerney, J. A., E.E. 1902
20 West 49th St., N. Y. City.

McCaffery, R. S., E.M. 1896
Mgr. Salt Lake Copper Co., Salt Lake City, Utah.

McCaskell, Jasper A., E.M. 1903
Care McCormick Bros., 71 Broadway, N. Y. City.

McClain, Henry G., A.B., E.M. 1906
Min. Eng. and Surveyor with the Liberty Bell Gold Mining Co., Telluride, Col.

McClelland, James Farley, E.M. 1900
Gen. Mgr. South Nevada Co., Tonopah, Nev.

McClelland, J. Bruce, B.S., A.M. 1897
Architect, 14 West 96th St., N. Y. City.

McClur, W. J., E.E. 1898
160 Fifth Ave., N. Y. City.

McConway, William, Jr., E.M. 1896
Supt. The McConway & Torley Co., Pittsburgh, Pa.

McCulloh, E. A., Ph.B. 1878
Glencoe, Md.

McCullough, R. A., B.S. (Arch.) 1899
Glencoe, Md.

McDowell, Frederick H., E.M. 1872

McDowell, Walter St. Ledger, C.E. 1903
Transitman for Mex. International R. R.

McIlhiney, Parker C., Ph.B., A.M., Ph.D. 1892
Consulting Chemist, 145 East 23d St., N. Y. City.

McIntyre, Henry K., E.E. 1899
Engineering Dept., New York Telephone Co., N. Y. City.

McIntyre, Malcolm, M.E. 1905
345 West End Ave., N. Y. City.

McKee, H. S., E.M. 1893
Currier Bldg., Los Angeles, Cal.

McKenna, Charles F., Ph.D. (Chem.) 1883
Consulting Chemist, 155 West 91st St., N. Y. City.

McKim, Alex. Rice, B.S. (Mass. Inst. Tech.), A.M. 1897
Practicing and Expert Architect, 36 East 28th St., N. Y. City.

McKim, Robert Albert, C.E. 1884
34 West 91st St., N. Y. City.

McKinlay, James Buell, E.M. 1892
25 Broad St., N. Y. City.

McKinlay, William Bradford, E.M. 1895
Newhouse, Utah.

McKinney, Francis W., C.E. 1906
Railroad Engr. and Purchasing Agent for La Dicha and Pacific R. R. Co.

McKleroy, William Henry, Met.E. 1890
Anniston, Ala.

McLaughlin, Cyril B., B.S. (Chem.) 1903
Amer. Sugar Refining Co., Jersey City, N. J.

McLean, J. M., E.E. 1897
204 West 36th St., N. Y. City.

McLellan, H., B.S. (Arch.) 1898
29 Rue Madame, Paris, France.

McLintock, Archibald 1900
Care Minera de Penoles, Ojuela, Durango, Mexico.

McLoughlin, Charles Swain, Ph.B. 1884
890 Broadway, N. Y. City.

McNeil, Charles R., Ph.B. (Arch.) 1894
Litchfield, Conn.

Maben, J. C., Jr., E.E. 1897
2241 Sycamore St., Birmingham, Ala.

MacDougall, C. W., E.M. 1903
Chief Engineer, Hancock Cons. Min. Co., Michigan.

MacGahan, Paul, E.E. 1896
511 Pitt St., Wilkinsburg, Pa.

MacKallor, De Witt C., E.M. 1906
Shift Boss, Alma de Maria Mine, San Isidro, Chihuahua, Mexico.

MacMullen, C. W., E.E. 1897
20 Broad St., N. Y. City.

MacTague, John J., E.M. 1883
Symen Durango, Mexico.

Machen, Charles Hudson, E.E. 1899
Pres. Machen & Mayer Elect. Mfg. Co., Philadelphia, Pa.

Machen, Henry B., C.E. 1898
Dept. of Water Supply, N. Y. City.

MacKaye, Harold Steele, C.E., LL.B., LL.M. 1887
Lawyer, 29 Liberty St., N. Y. City.

MACLAY, JAMES, C.E., PH.D. 1888
Professor of Mathematics, Columbia University, N. Y. City.

MACY, V. E., PH.B. (ARCH.) 1893
68 Broad St., N. Y. City.

MADDEN, J. H., C.E. 1897
308 West 30th St., N. Y. City.

MAEULEN, FREDERICK, E.M. 1902
Princes Bay, N. Y.

MAGALHAES, G. W., E.E. 1897
66 Orange St., Brooklyn, N. Y. City.

MAGHEE, JOHN HOLME, A.B., A.M., C.E. 1876
222 Pacific St., Jersey City, N. J.

MAGNUS, BENJAMIN, E.E. 1900
Metallurgical Engineer, 118 Pitt St., Sydney, Australia.

MAGRUDER, H. S., B.S. (ARCH.) 1898
Roland Park, Baltimore, Md.

MAINZER, H. R., B.S. (ARCH.) 1899
9 East 66th St., N. Y. City.

MAISENHOLDER, EDWARD F., C.E. 1903
Topographical Draftsman, Borough of the Bronx, N. Y. City.

MALCOMSON, A. SIDNEY, C.E. 1905
Engineering Corps, R. R. Com., Washington, D. C.

MALUKOFF, A. J., C.E. 1893
Dept. of Bridges, N. Y. City.

MANHEIMS, L. R., E.E. 1897
164 East 79th St., N. Y. City.

MANN, C. R., A.B., A.M. 1897
University of Chicago, Chicago, Ill.

MANN, HORACE BORCHSENIUS, PH.B. (ARCH.) 1890
Orange, N. J.

MANNHEIM, HERMANN CHARLES, E.M. 1887
Care Board of Executors, Salisbury, Rhodesia, Africa.

MANNHEIM, PAUL AUGUST LOUIS, E.M. 1885
With A. S. & R. Co., Maurer, N. J.

MAPES, CHARLES HALSTEAD, PH.B. (CHEM.) 1889
60 West 40th St., N. Y. City.

MAPES, CHARLES MAYNARD, C.E. 1902
Civil Engineer, 148th St. and Third Ave., N. Y. City.

MARBLE, RALPH N., JR., E.M. 1905
Ishpeming, Mich.

MARIE, LEON, E.M. 1885
Majestic Hotel, N. Y. City.

MARSH, JOHN R., E.M. 1887
606 East Adams St., Muncie, Ind.

MARSH, ROBERT, JR., E.M. 1907
Care Nevada Copper Co., McGill, Nev.

MARSTEN, CHARLES S., M.E. 1902

MARTIN, F. S., MECH.E. 1904
16 Hamilton St., Philadelphia, Pa.

MARTIN, L. TROWBRIDGE, E.E. 1898
56 West 33d St., N. Y. City.

MARTIN, RALPH, E.M. 1905
28 Hyde Park Gate, London, England.

MASON, F., C.E. 1898
781 Park Ave., N. Y. City.

MASSA, CHARLES GRISWOLD, C.E. 1889
Consulting Civil Eng., 84 Warren St., N. Y. City.

MASSA, L. F., C.E. 1890
Fort Lee, N. J.

MASTERS, HARRIS K., E.M. 1894
Gen. Mgr. Central Chili Copper Co., Ltd., Panulcillo, Coquimbo, Chili.

MATHEWS, JOHN ALEX., B.S., M.S., A.M., PH.D. 1895
Crucible Steel Co. of America, Syracuse, N. Y.

Mathis, T. S., E.M. 1879
49 South Main St., Salt Lake City, Utah.

Matsui, Nawokichi, Ph.B. (Chem.), Ph.D. 1878
Agricultural College, Konaba, Tokio, Japan.

Matthew, W. D., Ph.B. (Arch.) 1893
American Museum of Natural History, N. Y. City.

Matthews, Charles E., C.E. 1905
Asst. Engr., Belmont Tunnel, New York and Long Island R. R. Co.

Matthews, Charles Thompson, Ph.B. (Arch.) 1889
30 West 57th St., N. Y. City.

Matty, Leo Joseph, Mech.E., LL.D. 1903
Attorney-at-Law and Patent Counsel, 141 Broadway, N. Y. City.

Mayer, Lucius W., E.M. 1904
Federal Lead Co., Flat River, Mo.

Mayer, Ralph Edward, C.E. 1879
Adjunct Professor in Mechanical Drawing, Columbia University.

Mead, H. L., M.E. 1905
Arino, Durango, Mexico.

Meehan, John A., Mech.E. 1901
Sales Agent, The Triumph Electric Co., 1 Madison Ave., N. Y. City.

Meeks, Reginald, M.E. 1902
Chemist and Metallurgist, Jackson Bldg., Chicago, Ill.

Meikleham, Thomas Mann Randolph, C.E. 1890
44 Broad St., N. Y. City.

Meissner, Carl August, Ph.B. (Chem.) 1880
In office of Asst. to Pres., U. S. Steel Corporation, N. Y. City.

Melliss, D. Ernest, A.M., Ph.D. 1868
Consulting Engineer in San Francisco, Cal.

Menges, Charles P., E.E. 1904
Testing Dept., N. Y. Edison Co., N. Y. City.

Menges, Philip Charles, B.S., E.E. 1902
With Johnston Livingston, Jr., & Co., N. Y. City.

Menline, Isaac, C.E. 1898
With Snare & Triest, N. Y. City.

Mentzel, Charles, B.S., E.M. 1907
29 Broadway, N. Y. City.

Merklinger, Theodore E., E.E. 1907
850 South 15th St., Newark, N. J.

Merrill, Frederick James Hamilton, Ph.B. (Geol.), Ph.D. . . . 1885
Consulting Geologist, 20 East 42d St., N. Y. City.

Merritt, James Haviland, Ph.B. (Chem.), A.M. 1880
Architect, 3 Monroe Place, Brooklyn, N. Y. City.

Merritt, John I., M.E. 1907
Whitestone, L. I.

Merritt, Lucius R., Mech.E. 1906
Sound Beach, Conn.

Merry, Frederick Charles, E.M. 1902
With Ferguson Mines, Ltd., Ferguson, B. C.

Merwin, H. J., E.M. 1879
Middlesborough, Ky.

Merz, Eugene, B.S., E.M. 1892
President Ultramarine Co., Newark, N. J.

Mesa, Antonio Estaban, C.E. 1882
33 West 118th St., N. Y. City.

Mesereau, Gail, B.S. (Chem.) 1903
105 East 17th St., N. Y. City.

Meserole, Walter Montfort, C.E. 1881
44 Court St., Brooklyn, N. Y. City.

Messiter, E. H., C.E. 1894
Engineer, Robbins Conveying Belt Co., Park Row Bldg., N. Y. City.

Mettler, Arthur J. (Chem.) 1905
Chemist for the Fibre Conduit Co., Orangeburg, N. Y.

Metzger, Arthur, Ph.B. (Chem.) 1896
57 East 72d St., N. Y. City.

Meyer, Hans Frank, B.S., C.E. 1907

Meyer, Herman Henry Bernard, E.M. 1885
Chief of Periodical Division and Chief of Order Division, Library of Congress, Washington, D. C.

Middleton, John, C.E. 1887
City Surveyor of the Borough of Brooklyn, 2511 Atlantic Ave., Brooklyn, N. Y. City.

Miles, George Frederick, C.E. 1904
Terminal Engineer's Office, N. Y. C. & H. R. R. R., The Chelsea, West 23d St., N. Y. City.

Miller, Charles Lewis, E.M. 1885
Vice-Pres. American Steel & Wire Co., Pittsburgh, Pa.

Miller, Charles Watts, E.M. 1884
Asst. Mgr., Bagdad Chase Gold Mining Co., California.

Miller, George Alfred, Jr., E.E. 1901
146 Grove St., Montclair, N. J.

Miller, Rudolph Philip, C.E. 1888
Consulting Engineer, 527 Fifth Ave., N. Y. City.

Miller, Samuel O., C.E. 1895
Tutor in Drawing, Columbia Univ., and Consulting Engineer, N. Y. City.

Millett, Kenneth B., M.E. 1907
250 West 88th St., N Y. City.

Milliken, G. F., E.M. 1879
Union League Club, N. Y. City.

Mills, Henry Jayne, E.M. 1901
Thayer Mining and Milling Co., Miramar, Costa Rica, Central America.

Mills, Ronald V., E.M. 1906
Chemist, San Pedro Mines & Smelter, Santa Fé Gold and Copper Co., N. M.

Miltenberger, George, E.M. 1905
Phillipsburg, Montana.

Mitchell, H. B., E.E., A.M. 1898
Adjunct Prof. in Mathematics, Columbia University, N. Y. City.

Moeller, Edgar J., Ph.B. (Arch.) 1895
Architect, 7 West 38th St., N. Y. City.

Moeller, Rudolph, Ph.B. (Chem.) 1887
1007 Tinton Ave., Borough of the Bronx, N. Y. City.

Moen, Leclanche, Mech.E. 1903
With Niles, Bement & Pond Machine Tool Co., N. Y. City.

Moffatt, Miles Rees, B.S. (Chem.) 1901
Instructor in Chemistry, Lowell Textile School, Lowell, Mass.

Moisseieff, L. S., C.E. 1895
Dept. of Bridges, Park Row Bldg., N. Y. City.

Moldenke, Richard George Gottlob, E.M., Ph.D. 1885
Consulting Metallurgist, Watchung, Somerset Co., N. J.

Monell, Ambrose, Jr., E.E. 1896
Tuxedo Park, N. Y. City.

Monell, Joseph Thompson, C.E. 1889
Mech. and Elec. Engr., Alphaduct Mfg. Co., N. Y. City.

Monks, Richard A. (Associate) 1894
Contracting Engineer, 82 Beaver St., N. Y. City.

Monks, William D., Mech.E. 1907
353 South Third Ave., Mt. Vernon, N. Y.

Montenegro, M. R., E.M. 1890
314 River St., Hoboken, N. J.

Montgomery, H. P. A., Ph.B. (Arch.) 1896
Trail, B. C.

Mora, Mariano Luis, C.E. 1891
Gen. Electric Co., Foreign Dept., 44 Broad St., N. Y. City.

Morales, Luis, C.E. 1904
Havana, Cuba.

Moran, Daniel Edward, C.E. 1884
Vice-Pres. The Foundation Co., N. Y. City.

Morewood, George Barrow, E.M., Ph.D. 1878
156 West 76th St., N. Y. City.

Morewood, Henry Francis, E.M., Ph.D. 1876
86 Front St., N. Y. City.

MORGAN, J. A., A.M., E.E. 1902
Westinghouse Electric and Mfg. Co., Pittsburgh, Pa.

MORGAN, J. L., PH.B. (CHEM.) 1888
Treasurer, Gen. Chem. Co., 25 Broad St., N. Y. City.

MORGAN, WILLIAM FELLOWES, A.B., E.M. 1884
Pres. Harrison St. Cold Storage Co., Arch 5, Brooklyn Bridge, N. Y. City.

MORLEY, FREDERICK H., A.B., E.M. 1902
Consulting Mining Engineer, 412 McPhee Bldg., Denver, Col.

MORLEY, WILLIAM R., E.M. 1902
Manager Mines Exploration Co., Datel, Socono Co., New Mexico.

MORRILL, WILLIAM CHARLES, E.E. 1899
Sec. and Treas., The Nightingale Co., N. Y. City.

MORRIS, ALFRED B., E.E. 1906
190 West 100th St., N. Y. City.

MORRIS, B. W., JR., PH.B. (ARCH.) 1894
University Club, N. Y. City.

MORRISON, CHARLES E., C.E., A.M. 1901
Asst. Civil Engineering, Columbia University, N. Y. City.

MORSE, GEORGE T., PH.B. (ARCH.) 1896
9 Rue de la Université, Paris, France.

MORTIMER, H. C., E.E. 1898
105 East 57th St., N. Y. City.

MOSCHOWITCH, M., E.E., M.E. 1899
Care H. K. Geisler & Co., Griazaia 12, St. Petersburg, Russia.

MOSES, ALFRED JOSEPH, E.M., PH.D. 1882
Professor of Mineralogy, Columbia University, N. Y. City.

MOSES, PERCIVAL R., E.E. 1895
Consulting Engineer, 320 Fifth Ave., N. Y. City.

MOSLEY, R. K., PH.B. (ARCH.) 1889
1 Nassau St., N. Y. City.

MUIR, DOWNIE D., JR., E.M. 1906
Worcester, Mass.

MULFORD, ROBERT, E.M. 1884
With Allis-Chalmers Co., 71 Broadway, N. Y. City.

MULLER, GEORGE, PH.B. (CHEM.) 1887
Box 142, Hoboken, N. J.

MULLER, JULIUS, E.E. 1899
United Electrical Co., Newark, N. J.

MULLIKEN, HARRY B., PH.B. 1895
Architect, 7 West 38th St., N. Y. City.

MUNROE, HENRY SMITH, E.M., PH.D., DR.S. 1869
Prof. of Mining, Columbia University, N. Y. City.

MUNROE, M., E.E. 1894

MUNROE, OTIS MORTIMER, PH.B. (CHEM.) 1879
Banker, De Soto, Mo.

MUNSELL, CHARLES EDWARD, PH.B. (CHEM.), PH.D. 1878
Analyst and Asst. Chemist, F. W. Devoe and C. T. Raynolds Co., N. Y. City.

MURCHISON, K. M., JR., PH.B. (ARCH.) 1894
46 West 57th St., N. Y. City.

MURPHY, G. R., A.M., E.E. 1899
2699 Union St., San Francisco, Cal.

MURPHY, J. LEO, C.E. 1904
Asst. Engr., Board of Water Supply, N. Y. City.

MURPHY, WILLIAM ALOYSIUS, C.E. 1902
Treas. and Director of the James D. Murphy Co., 1181 Broadway, N. Y. City.

MURRAY, GEORGE, E.M. 1874
112 West 80th St., N. Y. City.

MYERS, DAVID MOFFATT, MECH.E. 1901
Consulting Engineer, 2001 Park Row Bldg., N. Y. City.

NATKINS, I., B.S., E.E. 1895
138 West 98th St., N. Y. City.

NAVARRO, JOHN ADALBERT, C.E. 1880
Gov. Inspector of the Vera Cruz and Pacific R. R., Puente de Alvarado, Mexico City, Mexico.

Nebeker, Aquilla C., E.M. 1906
172 East Third North St., Logan, Utah.

Necarsulmer, Edward, Ph.B. (Arch.) 1896
109 East 70th St., N. Y. City.

Neftel, Knight, C.E., Ph.D. 1879
7 East 42d St., N. Y. City.

Nelson, C. N., E.M. 1905
129 North Norwood Ave., Buffalo, N. Y.

Nelson, Francis Augustus, B.S. (Arch.) 1900
108 West 84th St., N. Y. City.

Nelson, John Maurice, B.S. (Nebraska), Ph.D. 1907
Rensselaer Polytechnic, Troy, N. Y.

Nesmith, James E., E.M. 1879
256 Henry St., Brooklyn, N. Y. City.

Nettre, L. R., E.M. 1869
Worcester House, Walbrook, London, England.

Neu, S. Sidney, E.E. 1901
Crocker-Wheeler Co., Ampere, N. J.

Newberry, S. B., E.M., Ph.D. 1878
Sandusky Portland Cement Co., Sandusky, Ohio.

Newbrough, William, A.B., E.M. 1884
Consulting Engineer, Evanston, Wyoming.

Newell, William, A.B., M.E. 1907
315 West 97th St., N. Y. City.

Newhouse, E. L., E.M. 1886
Director, Amer. S. & R. Co., 71 Broadway, N. Y. City.

Newman, M. L., E.E. 1898
253 West 143d St., N. Y. City.

Newton, T. M., Ph.B. (Arch.) 1893
40 West 75th St., N. Y. City.

Neyman, Percy, Ph.B. (Chem.), Ph.D. 1881
Bedford, Ohio.

Nichols, Harry Parmelee, E.M. 1887
277 Broadway, N. Y. City.

Nichols, Ralph, E.M., C.E. 1877
Gen. Mgr. Avino Mines of Mexico, Ltd., and Consulting Engr., Gabriel, Durango, Mexico.

Nicholson, John Michael, A.B., C.E. 1903
Draftsman and Asst. Engr., Long Island R. R., New York City.

Nicoll, Gilbert L., E.M. 1905
323 West 83d St., N. Y. City.

Nieder, Philip G., B.S. (Chem.) 1907
Fanwood, N. J.

Niemann, Edward, B.S., E.E. 1906
Eng. Apprentice with Westinghouse Elec. and Mfg. Co., Pittsburgh, Pa.

Noble, Charles Milton, E.M. 1879
Anniston, Ala.

Noble, Lewis S., E.M. 1885
929 Equitable Bldg., Denver, Col.

Nolan, Thomas, Ph.B. (Arch.) 1884
University of Pennsylvania, Philadelphia, Pa.

Nolthenius, Paul T., B.S. (Chem.) 1907
Heerengracht 132, Amsterdam, Holland.

Norris, D. H., E.M. 1877

Norris, Robert Van Arsdale, E.M. 1885
Consulting Engineer, 2d National Bank Bldg., Wilkesbarre, Pa.

Norseworthy, Howard R., E.M. 1904
557 West 124th St., N. Y. City.

Norton, L. H., E.M. 1886
Colorado Bldg., Denver, Col.

Noyes, James Atkins, Ph.B. (Chem.), A.B. 1878
1 Highland St., Cambridge, Mass.

Noyes, William Skaats, E.M. 1875
Consulting Mining Engineer, 819 Mills Bldg., San Francisco, Cal.

Nusim, M. I., M.E. 1905
Eng. Dept., Turbine Research Co., Lynn, Mass.

Oakes, J. C., B.S., Ph.B. (Arch.) 1893
423 West 21st St., N. Y. City.

Oakley, Walton Livingston, Mech.E. 1902
35 East 64th St., N. Y. City.

Obert, Casin Watson, Mech.E. 1902
Asst. Editor, *Engineering Record*, N. Y. City.

O'Connor, J. W. 1898
8 East 12th St., N. Y. City.

O'Connor, Michael Joseph, E.M., Ph.B. (Arch.) 1881
Little & O'Connor, Architects, 5 West 31st St., N. Y. City.

O'Connor, W. A., B.S. (Arch.) 1898
5 West 31st St., N. Y. City.

O'Donovan, Leo J., A.M., E.E. 1902
Reis & O'Donovan, Engineers and Contractors, 268 West 91st St., N. Y. City.

Of, Charles, E.M. 1896
892 Prospect Ave., Bronx, N. Y. City.

Okuma, Kingo, E.M. 1878
Nagasaki, Japan.

Olcott, Eben Erskine, E.M. 1874
Consulting Engineer, 36 Wall St., N. Y. City.

Olyphant, Robert M., Jr., Mech.E. 1906
3210 Delman Bldg., St. Louis, Mo.

O'Reardon, I., C.E. 1897
Greytown, Nicaragua.

Ormsbee, Alex. F., E.E. 1895
Contract Dept. of the New York and New Jersey Telephone Co.

Ormsbee, James Jackson, E.M. 1886
Supt. El Paso Sm. Works, El Paso, Texas.

Orner, G. D., E.E. 1899
West New Brighton, N. Y.

Osborn, Raymond Storms, Mech.E. 1907

O'Shea, James Edward, E.E. 1902
31 West 88th St., N. Y. City.

Oster (formerly Oseranski), Isaac Henry, C.E. 1889

Osterheld, T. W., E.M. 1886
Yonkers, N. Y.

Ott, Charles Adolph, C.E. 1906
2672 Briggs Ave., N. Y. City.

Otto, C. L., B.S. (Arch.) 1898
885 Bushwick Ave., Brooklyn, N. Y. City.

Owens, Robert Bowie, E.E. 1891
Prof. of Electrical Engineering, McGill University, Montreal, Canada.

Oxnard, James Guerrero, Ph.B. 1883
32 Nassau St., N. Y. City.

Page, George Stephen, E.M. 1885
Asst. Mgr. Park Works, Crucible Steel Co. of America, Pittsburgh, Pa.

Page, Robert Weise, B.S. (Chem.) 1901
New Durham, N. J.

Painter, Charles Albert, E.M. 1884
J. Painter & Sons, Pittsburgh, Pa.

Painter, George Edward, Ph.B. (Chem.) 1883
Director in Safe Deposit and Trust Co., Pittsburgh, Pa.

Painter, Robert K., E.M. 1896
Mgr. San Carlos Copper Co., San José, Tamaulipas, Mexico.

Palmenberg, Oscar W., B.S. (Chem.) 1902
Chemist for Interborough Rapid Transit Co., New York City.

Palmer, Austin P., E.E. 1906
Asst. Metropolitan St. Railway Co., N. Y. City.

Palmer, C. E., E.M. 1878
Gen. Supt. Guggenheim Exploration Co., 71 Broadway, N. Y. City.

Palmer, George A., C.E. 1896
922 Fifth Ave., N. Y. City.

Palmer, Montague, E.E. 1903
Engineer, Dept. of Bridges, N. Y. City.

Palmer, Walter S., B.S., E.M. (Univ. Nev.) 1907
Box 793, Reno, Nevada.

Parker, A. Mc., E.M. 1880
Engineer and Contractor, 21 Park Row, N. Y. City.

Parker, A. W., E.M. 1899
45 Broadway, N. Y. City.

Parker, Herschel Clifford, Ph.B. (Chem.) 1890
Adjunct Prof. in Physics, Columbia Univ., N. Y. City.

Parker, L. R., E.E. 1901
Interborough Rapid Trans. Co., Manhattan Railway Div., N. Y. City.

Parker, R. A., C.E. 1896

Parker, Richard Alex., C.E., E.M. 1878
Consulting Mining Engineer, 218 Boston Bldg., Denver, Col.

Parks, John Randolph, E.M. 1880
Consulting Mining Engineer, Spokane, Wash.

Parmley, Charles Howard, B.S., E.E. 1892
524 West 114th St., N. Y. City.

Parr, Harry L., A.B., Mech.E. 1904
Instructor in Mechanical Engineering, Columbia University, N. Y. City.

Parraga, Charles Frederick, C.E. 1883
56-58 Pine St., N. Y. City.

Parsons, Henry, C.E. 1888
1033 Madison Ave., N. Y. City.

Parsons, H. A., C.E. 1894
Stamford, Conn.

Parsons, William Barclay, A.B., C.E. 1882
Consulting Engineer, 22 William St., N. Y. City.

Parsons, W. E., B.S. (Arch.) 1898
156 Fifth Ave., N. Y. City.

Pattberg, Otto Frederick, E.M. 1898
Supt. and Gen. Mgr. of Montgomery Mining Co., Camden, N. C.

Pattison, Myron Adams, E.M. 1902
310 West 115th St., N. Y. City.

Payne, Clarence Quintard, E.M. 1882
99 John St., N. Y. City.

Payson, Harold, E.M. 1905
Bristol, R. I.

Pazos, Vincent Felix, E.M. 1878

Peacock, William T., M.E. 1907
Care Lackawanna Steel Co., Buffalo, N. Y.

Pearce, R., Ph.D. 1890

Peck, S. B., C.E., E.M. 1886
39th St. and Stewart Ave., Chicago, Ill.

Peck, T. B., Jr., E.E. 1898
11 Pine St., N. Y. City.

Pederson, Franklin M., E.E., Sc.D. 1893
Instructor in Mathematics, College City of New York.

Peele, Robert, E.M. 1883
Professor in Mining, Columbia University.

Pell, F. L., Ph.B. (Arch.) 1895
10 West 53d St., N. Y. City.

Pellew, Charles Ernest, E.M. 1884
Adjunct Professor of Chemistry, Columbia University.

Pelton, Edward F., B.S., E.M. 1902
Geologist of Detroit Copper Co., Morenci, Arizona.

Pelton, H. C., Ph.B. (Arch.) 1890
1133 Broadway, N. Y. City.

Pelton, Roger T., E.M. 1903
Engineer Copper Queen Consolidated Mining Co., Bisbee, Ariz.

Pemoff, Joel, C.E. 1896
1572 Washington Ave., N. Y. City.

Pennington, Joseph Pope, A.M. (Associate) 1868
80 Washington Square East, N. Y. City.

Peppmuller, R. H., Ph.B. (Arch.) 1895
152 West 130th St., N. Y. City.

Perkins, Henry A., E.E., M.A. 1899
Prof. of Physics, Trinity College, Hartford, Conn.

Perkins, Seymour, C.E. 1897
42 West 46th St., N. Y. City.

Perkins, T. S., Ph.B. (Chem.) 1888
39 Garden Place, Brooklyn, N. Y. City.

Perrin, H. C., Ph.B. (Arch.) 1895
Larchmont, N. Y.

Perrine, George, C.E. 1894
General Engineering, 820 West End Ave., N. Y. City.

Perry, Charles L., E.E. 1896
1 State St., Schenectady, N. Y.

Perry, Oscar Butler, E.M. 1900
71 Broadway, N. Y. City.

Peuguet, Charles Paul Ernest, C.E., A.M. 1895
Asst. Eng., Hudson Companies, 311 West 95th St., N. Y. City.

Pfister, Philip Charles, E.M. 1875

Pickard, Glenn H., B.S. (Chem.) 1904
Chemist, Spencer, Kellon Co., Buffalo, N. Y.

Pickering, John C., E.M. 1904
51 West 130th St., N. Y. City.

Pickhardt, William Paul, B.S. (Chem.) 1901
With Continental Color and Chemical Co., N. Y. City.

Pierce, Frederick E., C.E. 1892
With N. J. Zinc Co., 71 Broadway, N. Y. City.

Pierce, Harry Nelson, E.M. 1885

Pierce, W. L. S., E.E. 1905
Euclid Hall, N. Y. City.

Piez, Charles, E.M. 1889
Vice-Pres. and Chief Engineer, Dodge Coal Storage Co., Philadelphia, Pa.

Pigott, Reginald J. S., Mech.E. 1906
Asst. Engr., Power Sta., Interborough R. T. Co., N. Y. City.

Pigott, Stephen J., Mech.E. 1903
International Curtis Marine Turbine Co., N. Y. City.

Pilcher, L. F., Ph.B. (Arch.) 1895
Vassar College, Poughkeepsie, N. Y.

Pinkham, Herbert, C.E. 1895
Supt., Colonel J. J. Astor Estate, Rhinebeck, N. Y.

Pistor, William, E.M. 1868
Architect, 68 Broad St., N. Y. City.

Pitkin, Lucius, A.B., Ph.B. (Chem.) 1881
Analytical and Consulting Chemist, 47 Fulton St., N. Y. City.

Pitner, Paul J., E.M. 1905
Care V. M. Braschi, City of Mexico, Mexico.

Pitou, Eugene, Jr., C.E. 1906
Nat. Meter Co., 84 Chambers St., N. Y. City.

Platt, Charles Slason, E.M., Assayer 1868
29-31 Gold St., N. Y. City.

Plousky, Samuel Edward, B.S. (Arch.) 1900
50 West 88th St., N. Y. City.

Pocock, Cecil W., E.M. 1906
Min. Engr. for Santa Fé Gold Mining Co., San Pedro, New Mexico.

Polishook, Samuel N., C. E. 1906
Architects' Engr., John B. Snook's Sons, N. Y. City.

Pollak, L. L., E.E. 1905
60 West 119th St., N. Y. City.

Polledo, Ysidoso Ygnacio, E.M. 1885
Consulting Engineer, Manzaneda 16, Matanzas, Cuba.

Pomeroy, W. A., E.M. 1893
Waverley Ave., Palo Alto, California.

Pond, Charles M., Mech.E. 1903
With the Pratt & Whitney Shops of the Niles-Bement-Pond Co., N. Y. City.

Popcke, Arthur G., E.E. 1906
Eng. Apprentice with the Westinghouse Elec. and Mfg. Co., 913 Rebecca Ave., Wilkinsburg, Pa.

Pope, J. R., Ph.B. (Arch.) 1894
1133 Broadway, N. Y. City.

Porter, H. Hobart, E.M. 1886
Sanderson & Porter, Consulting and Contracting Engineers, 52 William St., N. Y. City.

Porter, Jesse C., E.M. 1905
Mining Engineer at Daiquiri, Cuba, for the Spanish-American Iron Co.

Porter, John Bonsall, E.M., Ph.D. 1882
Professor of Mining and Metallurgy, McGill Univ., Montreal, Canada.

Portuondo, José, C.E. 1890
St. Tomàs Alta 14, Santiago, Cuba.

Portuondo, J. M., C.E. 1895

Post, Abram Skidmore, C.E. 1884
81 Fulton St., N. Y. City.

Post, A. Van Z., C.E. 1889
Hayo dé Manicaragua, Cuba.

Post, R. B., Ph.B. (Arch.) 1893
44 West 44th St., N. Y. City.

Post, William Stone, Ph.B. (Arch.) 1890
Bernardsville, N. J.

Potter, William B., A.B., E.M. 1869
3312 Washington Ave., St. Louis, Mo.

Powell, Frederick, A.B., E.M. 1883
Engineer, Hammond Mfg. Co., Portland, Oregon.

Powell, F. J., E.M. 1905
331 East 17th St., N. Y. City.

Powers, Cornelius Van Vorst, Ph.B. 1882
231 West 125th St., N. Y. City.

Powers, Lewis J., Jr., E.M. 1884
Powers Paper Co., Holyoke, Mass.

Powers, Walter Hayward, E.E. 1902
Peet & Powers, Electrical Engineers and Contractors, N. Y. City.

Prentis, Edmund A., Jr., E.M. 1906
408 West 23d St., N. Y. City.

Preston, William Evan, C.E. 1889
With the Corps of Engineers, U. S. A.

Pretzfeld, Charles J., Ph.D. 1902
Pretzfeld & Co., 165 Water St., N. Y. City.

Primelles, José Alejandro, C.E. 1887
P. O. Box 121, Havana, Cuba.

Prince, A. D., C.E. 1903
122 Liberty St., N. Y. City.

Prince, John L., E.E. 1894
Inspection Dept. of the New York Edison Co., 59 Duane St., N. Y. City.

Proctor, William Ross, E.M. 1884
402 Lake Drive, Lakewood, N. J.

Prosser, Herman A., E.M., E.E. 1896
Metallurgical Director, U. S. Sm., Ref. and Min. Co., 100 B'way, N. Y. City.

Prout, Glover P., C.E. 1903
Embruville, Tenn.

Provost, Andrew J., Jr., C.E. 1889
Member of firm of Lederle & Provost, 39-41 West 38th St., N. Y. City.

Provot, F. A., C.E. 1893
Consulting Mining Engineer, 11 East 42d St., N. Y. City.

Provot, George, Ph.B. 1889
Architect, 11 East 42d St., N. Y. City.

Putnam, B. R., B.S., A.M. 1893
803 Redding St., Sacramento, Cal.

Putnam, Worcester, Mech.E. 1906
Yarmouthport, Mass.

Queneau, Augustin, L. J., E.M., A.M. 1901
Care Bewick, Moreing & Co., 62 London Wall, E.C., London, England.

Radford, William Helsham, E.M. 1877
Lydenburgh Gold Mining Co., Ltd., Manchester, England.

Rae, James Giles, C.E. 1901
Auditorium Bldg., Los Angeles, Cal.

Raisman, Aaron I., C.E. 1898
Asst. Engr., N. Y. Rapid Transit Commission.

Ralph, H. P., C.E. 1897
Smithtown, N. Y.

Randolph, Edmund, Ph.B. (Chem.) 1883
111 Broadway, N. Y. City.

Randolph, John C., A.B., A.M., E.M. 1869
15 Broad St., N. Y. City.

Rappold, G. W., Ph.B. (Arch.) 1897
760 Flushing Ave., Brooklyn, N. Y. City.

Ray, David H., A.B. (Coll. C. N. Y.), B.S. (Arch.), 1901, A.M., 1902, C.E. (N. Y. U.) 1902
555 West 182d St., N. Y. City.

Raymer, George Sharp, A.B., E.M. 1881
Harvard University, Cambridge, Mass.

Raymond, Max, C.E. 1898
Pier A, North River, N. Y. City.

Raymond, Robert Matthew, A.B., E.M. 1889
Gen. Mgr. El Oro M. and Ref. Co., Ltd., El Oro, Mexico.

Raymond, William O., Ph.B. (Arch.) 1896
17 Broadway, N. Y. City.

Raynor, R., Ph.B. (Chem.) 1889
969 Sixth Ave., N. Y. City.

Read, James P., M.S., E.E. 1906
W. S. Barstow & Co., N. Y. Supt. of Construction, N. Y. City.

Read, Thomas Thornton, E.M. 1902
Professor of Mining and Metallurgy, Colorado College, Colorado Springs, Col.

Reckhart, Daniel William, E.M. 1884
Proprietor, Independent Assay Office, El Paso, Texas.

Reed, David Carlyle, E.M., C.E. 1900
Care Frank Klepetko, 307 Battery Park Bldg., N. Y. City.

Reed, Sylvanus Albert, A.B., A.M., E.M., Ph.D. 1887
Consulting Engineer, University Club, N. Y. City.

Reese, William W., A.B., E.E. 1892
New Hamburgh, N. Y.

Reeve, F. C., E.E. 1895
10 Ogden St., Newark, N. J.

Regan, George W., E.E. 1896
352 Degraw St., Brooklyn, N. Y. City.

Reich, William J., Mech.E. (1888 Vienna), A.M. 1902
Engineer and Contractor, 810 Coal St., Wilkinsburg, Pa.

Reid, Eugene J., E.E. 1904
1200 Franklin Ave., N. Y. City.

Reis, Leslie Robert, Mech.E. 1902
Consulting Engineer, 609 West End Ave., N. Y. City.

Renault, George, C.E. 1883
170 West 87th St., N. Y. City.

Rennard, John C., E.E. 1894
15 Dey St., N. Y. City.

Renner, Frank A., C.E. 1907
2065 Valentine Ave., N. Y. City.

Restrepo, C. C., E.M., C.E. 1887
Medellin, Republic of Colombia, South America.

Reyna, J. E., E.E. 1898
Flaguiltenango, Morales, Mexico.

Reynolds, M., A.B., Ph.B. (Arch.) 1893
98 Columbia St., Albany, N. Y.

Rhame, John F., E.E. 1906
Wantagh, Nassau Co., N. Y.

Rhodes, Francis Bell Forsythe, E.M. 1874
Supt. U. S. Zinc Co., Pueblo, Col.

Rhodes, Robert D., E.M. 1879
Consulting Engineer, New Brighton, N. Y. City.

Rice, George Samuel, E.M. 1887
Consulting Engineer, 734 Rookery Bldg., Chicago, Ill.

Richards, Howard, Jr., E.E. 1903
Science Dept. of the Boone College, Wuchang, China.

Richardson, J. C., E.M., C.E. 1883
Middlesborough, Ky.

Richmond, Julian Pierre William, Mech.E. 1902
Asst. Engr., Board of Water Supply, N. Y. City.

Richmond, William Thomas, Ph.B. 1881
244 West 116th St., N. Y. City.

Ricketts, Pierre de Peyster, E.M., Ph.D. (Chem.) 1871
Consulting Engineer, 104 John St., N. Y. City.

Riedal, C. Oscar, Mech.E. 1904
Draughtsman, N. Y. Edison Co., N. Y. City.

Riedel, A. E., Mech.E. 1896
231 Pennsylvania Block, Butte, Montana.

Riederer, E. J., B.S. (Chem.) 1897
Landing, N. J.

Riederer, Herman S., A.M., Ph.D. 1901
P. O. Box 410, Bristol, Tenn.

Ries, Heinrich, Ph.B., A.M., Ph.D. 1892
Professor of Geology, Cornell University, Ithaca, N. Y.

Rigby, S. F., E.M. 1902
Consulting Engineer, 137 Keith Building, Salt Lake City, Utah.

Riggs, George Washington, Ph.B. 1871
46 East 29th St., N. Y. City.

Riker, C. L., Ph.B. (Arch.) 1895
125 East 62d St., N. Y. City.

Ring, Ambrose E., E.M. 1905
Surveyor and Draftsman with Harper, Macdonald & Co., Butte, Mont.

Rionda, José Bernardo, C.E. 1901
Sancti Spiritus, Cuba.

Rionda, Leander J., Mech.E., C.E. 1902
With Czarnikow, MacDougall & Co., 112 Wall St., N. Y. City.

Rionda, Manuel E., E.E. 1900
141 West 93d St., N. Y. City.

Riter, Levi E., Jr., E.M. 1899
124 Keith Building, Salt Lake City, Utah.

Roberts, A., E.M. 1902
Goldfields, Nevada.

Roberts, Arthur Carr, E.M. 1881

Roberts, John T., Jr., E.M. 1907
350 Main St., Buffalo, N. Y.

Robertson, Kenneth, E.M. 1868
Care Amer. Steel and Wire Co., Allegheny, Pa.

Robertson, Richard Spotswood, Jr., E.M. 1871
Jackson, Minn.

Robinson, Arthur, E.M. 1901
17 East 49th St., N. Y. City.

Robinson, F. G., E.E. 1893
106 West 51st St., N. Y. City.

Robinson, Henry Alwood, Ph.B. 1880
621 Broadway, N. Y. City.

Rochester, T. W., E.E. 1905
845 Lexington Ave., N. Y. City.

Roden, Benjamin F., Jr., E.M. 1906
Gen. Mgr. Central Coal Co., Birmingham, Alabama.

Rodenburg, Charles, C.E. 1896
Asst. Engr., N. Y. Rapid Transit Commission, 320 Broadway, N. Y. City.

Roell, Antone Joseph, C.E. 1901
523 East 88th St., N. Y. City.

Roeser, Frederick, B.S., E.M. 1884
Care Arkansas Valley Plant, Leadville, Col.

Rogers, A. P., Ph.B., C.E. 1898
49 West 57th St., N. Y. City.

Rogers, Charles E., C.E. 1897
6 West 125th St., N. Y. City.

Rogers, Charles Louis, E.M., C.E. 1877
Cincinnati, Ohio.

Rogers, Oscar L., Ph.B. (Arch.) 1889

Rogers, Robert B., E.M. 1905
Representative of New York Syndicate in Cobalt, Ontario, Canada.

Rodriguez, Varela F., E.M. 1903
Nopaltita y Anexas Mine, Compañia Minera y Fundidora de Mazapil, Zacatecas, Mexico.

Rohlfs, Otto D., E.M. 1905
Ely, White Pine Co., Nevada.

Rolker, Charles M., E.M. 1875
Consulting Engineer, Leadenhall Bldg., No. 1 Leadenhall St., London, England.

Rolle, Sidney, E.M. 1905
348 West 118th St., N. Y. City.

Roman, Joseph Martin, E.E. 1900
Atlanta, Ga.

Rood, R. G., Ph.B. (Chem.) 1884
315 Madison Ave., N. Y. City.

Ropes, W., C.E. 1898
21 Alpha Place, New Rochelle, N. Y.

Ros, Juan Pablo, B.A. (Havana University), E.M. 1898
Asst. Chief Engineer of Sta. Clara Province, Cuba.

Rosenblatt, Girard B., E.E. 1902
52 East Granite St., Butte, Mont.

Rosenthal, Albert, C.E. 1892
Supt. Mt. Vernon District Gas Dept., 123 South 8th Ave., Mt. Vernon, N. Y.

Rosenthal, Leon Walter, E.E. 1902
Electrical Eng. Dept., N. Y. C. & H. R. R. R. Co.

Ross, Samuel McNutt, Mech.E. 1902
Care Dr. W. S. Ross, Altoona, Pa.

Ross, William Coleman, C.E., E.M. 1876
Wellsville, N. Y.

Rossberg, W. N., E.M. 1904
Bingham, Utah.

Rossi, A. J., E.M. 1896
Supt. Roessler & Hasslacher Chem. Co., Perth Amboy, N. J.

Rothschild, Walter L., A.B., C.E. 1907
440 West End Ave., N. Y. City.

Rowland, Charles Bradley, C.E. 1884
The Continental Iron Works, Brooklyn, N. Y. City.

Rubidge, Frederick Taber, E.M., C.E. 1901
Asst. Supt. of Mines, New Jersey Zinc Co., Franklin Furnace, N. J.

Rupp, Philip, Ph.B., M.D. 1884

Rutherford, Lewis Hopkins, E.M. 1887

Rutherfurd, F. M., E.M. 1879
220 Fourth Ave., N. Y. City.

Ruttmann, Ferdinand, E.M. 1880
Wurtsboro, N. Y.

Ryon, Augustus Meader, E.M. 1886
Consulting Engineer, 89 Main St., Flushing, N. Y. City.

Sage, Darrow, E.E. 1901
Supt. Park Row Building, Nos. 13-21 Park Row, N. Y. City.

Sage, Edward Eugene, C.E. 1877
U. S. Assay Office, 30 Wall St., N. Y. City.

Sales, Keno Haber, E.M. 1900
Box 457, Butte, Mont.

de Sallier, Rene A., E.M. 1905
Chief Asst. to R. M. Atwater & Co., Helena, Mont.

Sanders, Wilbur E., E.M. 1885
Helena, Montana.

Sanger, Charles F., E.E. 1904
200 West 112th St., N. Y. City.

Sanguinetti, Philip C., Mech.E. 1903
Warwick, Mitchell & Co., 79 Wall St., N. Y. City.

Saqui, Emanuel, E.E. 1907
2026 Seventh Ave., N. Y. City.

Satterlee, Edward Lansing, Ph.B. (Arch.) 1900
287 Fourth Ave., N. Y. City.

Saunders, George Crosby, B.S., C.E. 1898
Mgr. Philadelphia office of Osborn Engineering Co.

Savage, Seward Merrill, C.E. 1892
2260 Pacific St., Brooklyn, N. Y. City.

Sawyer, Charles Pike, Ph.B. 1881
20 Vesey St., N. Y. City.

Sayres, Edward Laurence, A.B., C.E. 1903
P., N. Y. & L. I. R. R. Co., 218 West 121st St., N. Y. City.

Sayers, J. H., C.E. 1897
452 Classon Ave., Brooklyn, N. Y. City.

Sayres, Mortimer F., E.M. 1907
Box 2127, Bisbee, Arizona.

Schaefer, Ludwig, B.S. 1907
Broadway and 27th St., Paterson, N. J.

Scharf, Henry Warren, E.E. 1901
Interurban Street Railway Co., 621 Broadway, N. Y. City.

Schaus, Carl J., E.E. 1904
Eng. Dept. Gen. Elect. Co., Schenectady, N. Y.

Schell, R. Montgomery, Ph.D., B.S. 1895
With Bannister & Schell, Architects, 69 Wall St., N. Y. City.

Schermerhorn, Frederick Augustus, E.M. 1868
Trustee, Columbia University.

Schieffelin, William Jay, Ph.B. (Chem.), Ph.D. (Munich) . . 1887
Schieffelin & Co., 170 William St., N. Y. City.

Schimmel, J., Jr. 1898
Salisbury, Md.

Schlecht, W. W., C.E. 1897
446 East 57th St., N. Y. City.

Schlichter, W. I., E.E. 1896
127 West 58th St., N. Y. City.

Schlosser, Philip, Mech.E. 1902
4 East 92d St., N. Y. City.

Schmidt, Carl Gustav Adolph, Mech.E. 1901

Schmidt, F. S., E.M. 1903
90 Seventh Ave., N. Y. City.

Schmitt, Frederick W., E.M. 1906
Lewiston, Mont.

Schneider, Albert Francis, E.M., C.E. 1876
Consulting Engineer, 77 Pine St., N. Y. City.

Schneider, Carl A., E.E. 1904
Care The Connecticut Co., Ford Building, New Haven, Conn.

Schoen, Eugene John, B.S. (Arch.) 1902
57 Second Ave., N. Y. City.

Schreiber, Carl T., Mech.E. 1904
Mech. Eng. in Power Plant Dept., W. S. Barstow & Co., N. Y. City.

Schroeder, H., E.E. 1899
Flushing, N. Y. City.

Schroeder, J. Langdon, C.E. 1889
Architect, 5 West 31st St., N. Y. City.

Schroeter, George A., E.M. 1893
Consulting Engineer, 111 Broadway, N. Y. City.

Schulte, E. B. N., E.E. 1899
1409 Tenth St., Altoona, Pa.

Schultz, Robert S., Jr., E.M. 1906
With Victoria Copper Mining Co., Victoria, Mich.

Schumann, Charles Henry, C.E. 1888
Architect and Civil Engineer, 280 Broadway, N. Y. City.

Schwabacher, Frank, E.E. 1904
1900 Jackson St., San Francisco, Cal.

Schwansflugel, Charles A., C.E. 1907
898 Tenth Ave., L. I. City, L. I.

Schwarz, S. A., C.E. 1905
242 East 50th St., N. Y. City.

Schwarzkopf, William, E.E. 1906
Construction Engr. for Westinghouse Elec. and Mfg. Co., N. Y. City.

Schwegler, George, C.E. 1905
293 Lenox Ave., N. Y. City.

Schwerin, Clarence Maurice, E.M. 1901
Milwaukee Coke and Gas Co., Milwaukee, Wis.

Schwerin, Martin, E.M. 1903
Consulting Engineer, 49 Wall St., N. Y. City.

Scott, A. C., E.M. 1905
436 Westfield Ave., Elizabeth, N. J.

Scudder, Hewlett J., E.E., M.A. 1899
Gen. Electric Co., Schenectady, N. Y.

Searle, Charles D., C.E. 1894
Asst. Engr. with Rapid Transit Commission, N. Y. City.

Seelig, Alfred E., E.E. 1907
1236 Madison Ave., N. Y. City.

Seifert, Frederick H., E.M. 1906
255 Hancock St., Jersey City, N. J.

Seifert, Karl Francis Joseph, B.S. (Arch.) 1902
540 East 157th St., N. Y. City.

Seil, Harvey A., B.A., Ph.D. 1906
Chemist for G. F. Harvey Co., Saratoga Springs, N. Y.

Seldner, Rudolph, Ph.B. (Chem.), B.S. 1894
Mfg. Chemist, 1395 Dean St., Brooklyn, N. Y. City.

Self, E. D., E.M., M.E. 1894
Care Lockwood National Bank, San Antonio, Texas.

Seligman, J. G., E.M. 1887
612 West 112th St., N. Y. City.

Serber, David C., C.E. 1896
1522 Madison Ave., N. Y. City.

Sergeant, E. M., E.E. 1896
Boonton, N. J.

Seringhaus, Frederick W., Jr., E.E. 1904
Gen. Elect. Co., New York Office.

Sessinghaus, Gustavus, E.M., M.S. 1898
Mgr. Thunderbolt Leasing and Mining Co., San Juan Co., Col.

Sewall, Frank H., A.B., C.E. 1906
37 West 22d St., N. Y. City.

Shack, Albert P., E.M. 1868

Share, William Waldemar, Ph.B. (Chem.), Ph.D. 1881
Prof. of Chemistry and Geology, Adelphi College, Brooklyn, N. Y. City.

Shattuck, L. R., B.S., C.E. 1895
Sanderson and Porter, Engineers and Contractors, 52 William St., N. Y. City.

Shaw, Silas Frederick, E.M. 1903
Supt. Granadena Mill, Sta. Barbara, Mexico.

Sherman, F. D., Ph.B. 1884
Professor of Graphics, Columbia University, N. Y. City.

Sherman, G. F., C.E. 1894
Asst. Supt. Copper Queen Cons. Min. Co., Bisbee, Arizona.

Sherman, Henry C., A.M., Ph.D. (Chem.) 1896
Prof. of Organic Analysis, Columbia University.

Sherrer, Josef Anton, B.S. (Arch.) 1902
415 Indiana Trust Co., Indianapolis, Ind.

Sherron, G. Austin, E.M. 1904
With Combination Mines Co., Goldfields, Nevada.

Shields, Harold, C.E. 1905
Nicholson, Pennsylvania.

SHIMPER, J. F. VON, E.M. 1902
Bressler's Flat, Orange Free State, South Africa.

SHIRE, EDWARD I., PH.B. (ARCH.) 1896
109 East 61st St., N. Y. City.

SHOPE, HENRY BRENGLE, PH.B. 1885
19 West 32d St., N. Y. City.

SHRADY, CHARLES D., C.E. 1895
Allentown, Pa.

SHREVE, JOHN NELSON, E.M. 1902
Treas. and Director, Magnet Wire Co., 42 Broadway, N. Y. City.

SHRIVER, HARRY TOWER, PH.B. (CHEM.) 1888
Iron Foundry Works, Harrison, N. J.

SIMPSON, KENNETH M., A.M., E.M. 1906
Beaver Falls, Pa.

SIGMUND, BENJAMIN J., C.E. 1906
Asst. Engr. in Reinforced Concrete Construction, Tucker & Vinton, N. Y. City.

SILVERMAN, HERBERT L., E.M. 1905
30 East Broadway, Butte, Montana.

SIMONDS, FRANCIS MAY, E.M., PH.D. (CHEM.) 1887
Burns, 159 Front St., N. Y. City.

SIMONSON, L. M., C.E. 1899
Pelham, N. Y.

SEWARD, JOHN, E.M. 1895
Box 517, Tonopah, Nevada.

SINCLAIR, J. EDWIN, B.S. (CHEM.) 1906
Lecturer in Chemistry, Columbia University.

SINDEBAND, MAURICE L., E.E. 1907
105 East 90th St., N. Y. City.

SINGER, GEORGE, E.M. 1880
Pittsburgh Club, Pittsburgh, Pa.

SINGER, GEORGE HARTON, E.M. 1880
With the Crucible Steel Co. of America, 924 Park St., Allegheny, Pa.

SKIDMORE, SAMUEL TREADWELL, A.B., PH.B. (ARCH.) 1889
71 West 50th St., N. Y. City.

SKINNER, ELMER, C.E. 1891

SLACK, CHARLES G., E.M. 1884
328 Fourth St., Marietta, Ohio.

SLADE, RICHARD EDWARD, PH.B. 1887
Treas. and Gen. Mgr., Hartford City Gas Light Co., Hartford, Conn.

SLAVEN, R. E., E.E. 1899
With Chase Granite Co., Blue Hill, Maine.

SLOANE, THOMAS O'CONNOR, A.B., A.M., E.M., PH.D. 1872
South Orange, N. J.

SLOANE, T. O'CONNOR, JR., E.E. 1903
Engineer and Contractor, 60 Wall St., N. Y. City.

SMALL, FRANKLIN MAURICE, PH.B. (ARCH.) 1889
265 Broadway, N. Y. City.

SMALLWOOD, JULIAN C., MECH.E. 1903
Instructor in Mech. Eng., George Washington Univ., Washington, D. C.

SMEATON, WILLIAM HENRY, C.E., E.M. 1877
70 Washington Place, N. Y. City.

SMEDBERG, HENRY ASHTON, A.B., C.E. 1884
51 West 11th St., N. Y. City.

SMILLIE, SHELDON, E.M. 1904
Asst. Mining Engr., Quincy Mining Co., Hancock, Mich.

SMITH, AUGUSTUS, A.B., C.E. 1889
Consulting Engineer, 149 Broadway, N. Y. City.

SMITH, A. C., E.M. 1905
621 Pine St., Boulder, Col.

SMITH, EDWARD PERCY, MECH.E. (CORNELL), E.M. 1901
Tombstone, Ariz.

SMITH, ELBERT O., JR., C.E. 1905
542 West 159th St., N. Y. City.

SMITH, FRANK GERARD, E.E. 1900
5 Monroe St., New Rochelle, N. Y.

SMITH, FRANK MARSHALL, E.M. 1889
Mgr. of East Helena Plant, Amer. Sm. and Ref. Co., East Helena, Mont.

Smith, F. P., Ph.B. (Chem.) 1888
Dow & Smith, Chemical Engineers, 24-26 East 21st St., N. Y. City.

Smith, H. A., Ph.B. (Arch.) 1893
127 West 58th St., N. Y. City.

Smith, H. Raymond, M.E. 1907
122 Park Place, Brooklyn, N. Y. City.

Smith, Lenox, A.B., A.M., E.M. 1868
Agent for R. R. Interests, 71 Broadway, N. Y. City.

Smith, Lucien Easter, B.S. (Arch.) 1901
460 Manhattan Ave., N. Y. City.

Smith, O. B., Jr., B.S. (Arch.) 1897
61 Franklin St., Morristown, N. J.

Smith, R. W., E.E. 1903
361 West 22d St., N. Y. City.

Smith, Webster Temple, E.M. 1904
Mgr. Cushman & Smith Ochre Works, Bennington, Vt.

Smith, William Allen, E.M. 1898
United Zinc and Chemical Co., Iola, Kansas.

Smith, Wilson Fitch, C.E. 1894
Division Engineer, Board of Water Supply of the City of New York.

Smyth, Charles Henry, Jr., Ph.B. (Chem.), Ph.D. 1888
Professor of Geology, Princeton University, Princeton, N. J.

Smyth, Roland Mulvill, E.M., C.E. 1877
452 Produce Exchange, N. Y. City.

Snedeker, Clarence F., E.E. 1905
Elect. Dept., L. I. R. R. Co., N. Y. City.

Snook, Thomas Edward, E.M. 1884
Member of firm and Chief Engineer for John B. Snook & Sons, N. Y. City.

Soloman, Isaac Rosh, E.E. 1902
Chief Electrician, Navy Yard, Pensacola, Fla.

Soloman, Nathan Clarence, E.E. 1900
522 West 150th St., N. Y. City.

Solow, Alexander S., B.S., C.E. 1904
Asst. Engr., R. T. Com., N. Y. City.

Soper, George A., Ph.D. 1899
Consulting Engineer and Sanitary Expert, 29 Broadway, N. Y. City.

Spaulding, M. B., E.M. 1895
Gen. Mgr. Peruvian Sm., Ref. and Min. Co., 90 Wall St., N. Y. City.

Spencer, James B., Mech.E. 1906
Asst. Engr. with the James Reilly Repair and Supply Co., N. Y. City.

Speyers, Clarence Livingston, Ph.B. (Chem.) 1884
New Brunswick, N. J.

Spiller, R. L., C.E. 1900

Spiro, Walter Jesse, A.B., Mech.E. 1903
Supt. Columbia Typewriter Co., N. Y. City.

Spooner, Allen Newhall, C.E. 1886
Dept. of Docks and Ferries, 24th St. and East River, N. Y. City.

Stallnecht, Frederick, E.M. 1868
32 Waverley Place, N. Y. City.

Stander, Isaac, C.E. 1897
Dept. of Docks, Pier A, North River, N. Y. City.

Stangland, Robert S., Mech.E. 1904
157 West 123d St., N. Y. City.

Stanley, R. E., E.M. 1901
Asst. Gen. Supt., the Oxford Copper Co., Bayonne, N. J.

Stanton, Frank McMillan, E.M. 1887
Agent, Atlantic Mining Co., Houghton, Mich.

Staral, Frank T., Jr., E.M. 1904
Caxton Bldg., Cleveland, Ohio.

Starek, Emile, LL.B., LL.M., E.M. 1885
907 Chemical Bldg., St. Louis, Mo.

Starr, Charles C., A.M. 1902
Supt., Hardshell and Flux Mines, Patagonia, Arizona.

Starr, C. D. 1881

Starr, Henry F., Ph.B. (Chem.) 1879
61 Beekman St., N. Y. City.

Staunton, J. A., Jr. 1887
Sagada, Lepanto-Bontoc Province, Philippine Islands.

Staunton, William Field, E.M. 1882
Director and Gen. Mgr. of Tombstone Cons. Mine Co., Tombstone, Arizona.

Stearns, Thomas Beale, E.M. 1881
Mining and Manufacturing Machinery, 1720 California St., Denver, Col.

Steegmuller, C. A. C., C.E. 1905
171 Eleventh St., L. I. City, L. I.

Steel, A. A., E.M. 1900
Assoc. Prof. of Geology and Mining, Univ. of Arkansas, Fayetteville, Arkansas.

Steers, James Richard, Ph.B. (Chem.) 1890
37 East 67th St., N. Y. City.

Stein, Charles R., C.E. 1904
With P., N. Y. & L. I. R. R. Co.

Steinam, J. L., Ph.B. (Arch.) 1894
31 West 95th St., N. Y. City.

Steinbach, George E., B.S. (Arch.) 1899

Steinback, Gustave Erwin, B.S. (Arch.) 1900
52 Barclay St., N. Y. City.

Steindler, Henry, C.E. 1904
218 West 143d St., N. Y. City.

Stern, Henry, Ph.B. (Arch.) 1896
239 East 69th St., N. Y. City.

Stevens, Alexander, C.E. 1887
157 East 67th St., N. Y. City.

Stevens, Earl C., E.M. 1905
Asst. City Engineer of Billings, Mont.

Stevens, Oscar E., E.E. 1906
Far Rockaway, L. I.

Stewart, Charles A., A.B. (1906), A.M. 1907
Columbia University, N. Y. City.

Stewart, Howard Race, E.M. 1902
Imperial Copper Co., Silver Bell via Redrock, Arizona.

Stewart, Hunter, E.M. 1875

Stewart, John Burgoyne, E.M. 1901
Supt. Cyanide Dept., Peregrina Mining and Milling Co., Guanajuato, Mexico.

Stewart, John Henry, C.E. 1895
Consulting Engineer, 132 West 12th St., N. Y. City.

Stilwell, A. G., B.S. (Arch.) 1898
36 Gold St., N. Y. City.

Stilwell, H. A., E.M. 1903
187 Marlboro Road, Brooklyn, N. Y. City.

Stinson, Joseph Whittla, B.S., C.E. 1907

St. John, Thomas Matthew, Met.E. 1890
848 Ninth Ave., N. Y. City.

Stone, George Cameron, Ph.B. (Chem.) 1879
The New Jersey Zinc Co., 71 Broadway, N. Y. City.

Stone, Mason A., Jr., Mech.E. 1903
82 Beaver St., N. Y. City.

Stoughton, Arthur Alex., Ph.B. 1888
Architect, 1665 Washington Ave., N. Y. City.

Stoughton, Charles William, C.E. 1889
1665 Washington Ave., N. Y. City.

Stout, J. S., Jr., A.B., E.E. 1897
35 East 67th St., N. Y. City.

Stoutenburgh, C. H., E.E. 1905
Law Dept. of the City of New York, 110 West 77th St., N. Y. City.

Stover, Roderick, E.E. 1903
Pres. Southwestern Electric and Construction Co., Albuquerque, New Mexico.

Stratford, T. A., C.E. 1899
397 Flatbush Ave., Brooklyn, N. Y. City.

Strauss, Lester, E.M. 1900
Consulting Engineer, Care Julio L. East, Lima, Peru.

Strieby, William, A.M., E.M. 1878
Colorado Springs, Col.

Strong, Chester F., E.E. 1904
Testing Dept., Gen. Elect. Co., Schenectady, N. Y.

Strong, R. M., Mech.E. 1905
Care U. S. Geological Survey, Technologico Branch, Washington, D. C.

Strout, William Allen, Ph.B. (Arch.) 1891
80 St. James St., Brooklyn, N. Y. City.

Struthers, Joseph, Ph.B. (Chem.), Ph.D. 1885
Editor Amer. Inst. of Min. Engineers, 29 West 39th St., N. Y. City.

Stuart, William Henry, C.E. 1886
179 Scotland Road, South Orange, N. J.

Stuhrman, Edward A., C.E. 1907
299 Tenth St., Brooklyn, N. Y. City.

Sturgis, Edward Barney, E.M. 1895
Civil Engineer, 307 East 17th St., N. Y. City.

Sundheimer, Arthur I., E.E. 1907
234 West 137th St., N. Y. City.

Sussman, Max H., E.E. 1906
Mohegan, Conn.

Suter, George Augustus, E.M. 1883
Eng. and Contractor for Steam Power, etc., 42 Elm St., New Rochelle, N. Y.

Sutro, H. H., B.S. (Arch.) 1898
126 Liberty St., N. Y. City.

Sutton, F., E.E. 1895
91 Wall St., N. Y. City.

Suydam, Albert G., E.M. 1906
Otto, Coahuila, Mexico.

Suydam, John Richard, Jr., E.M. 1879
414 Madison Ave., N. Y. City.

Swain, Alfred Ernest, E.M. 1881
Supt. Amer. Zinc. Extraction Co.'s Mines at Parrall. Chihuahua, Mexico.

Swart, Clifford T., Mech.E. 1904
226 South Second Ave., Mt. Vernon, N. Y.

Swartz, Charles C., A.M., E.M. 1904
Supt. Zinc Mines, Joplin, Mo.

Tachan, William G., Ph.B. (Arch.) 1896
57 Highland Ave., Yonkers, N. Y.

Talcott, M. Gardner, E.M. 1905
Clifton, Arizona.

Tanz, Isadore, B.S., E.E., A.M. 1906
N. Y. Telephone Co., N. Y. City.

Tatlock, James Lloyd, C.E. 1898
Office of Eng. of Bridges, B. & O. R. R., Baltimore, Md.

Taylor, A. S. G., B.S. (Arch.) 1897
24 East 23d St., N. Y. City.

Taylor, Henry B., E.M. 1906
Care J. B. Taylor Dry Goods Co., Kansas City, Mo.

Taylor, J. B., E.M. 1888
945 President St., Brooklyn, N. Y. City.

Taylor, Richard M., C.E. 1907
256 Main St., Belleville, N. J.

Temple, S. J., Ph.B. (Arch.) 1892
Davenport, Iowa.

Tennille, George F., Ph.B. (Chem.) 1894
District Mgr. of Southern Cotton Oil Co., Savannah, Ga.

ter Meer, Henry C., E.E. 1901
90 New England Ave., Summit, N. J.

Terry, R. Rufo, Mech.E. 1904
Sterling Co., Barberton, Ohio.

Tetley, Thomas R., Jr., C.E. 1904
Asst. Engr. on N. Y. State Barge Canal, Fulton, N. Y.

Thacher, Arthur, C.E., E.M. 1877
420 Roe Bldg., St. Louis, Mo.

THAYER, REGINALD H., E.M. 1901
With Copper Queen Consolidated Mining Co., Bisbee, Arizona.

THOMAN, WILLIAM F., A.B., C.E. 1906
312 West 87th St., N. Y. City.

THOMAS, CHARLES S., JR., E.M. 1906
Gen. Mgr. and Chief Eng. for Marvin Ish & Bro., Goldfield, Nevada.

THOMAS, FREDERICK MAYHEW, E.M. 1885
Chief Engineer to Skaneateles Sewer Com., Skaneateles, N. Y.

THOMAS, W. S., E.M. 1898
Box 950, Goldfield, Nevada.

THOMES, E. H., PH.B., C.E. 1895
150 Willett St., Jamaica, N. Y. City.

THOMPSON, HENRY C., C.E. 1886
Larch Ave., Bogota, N. J.

THOMPSON, JOHN FAIRFIELD, B.S. (CHEM.) 1903
Oxford Copper Co., New Brighton, S. I., N. Y. City.

THOMPSON, MILTON STRONG, PH.B. (CHEM.) 1875
Newburyport, Mass.

THOMPSON, S. C., A.B., E.M. 1893
P. O. Box 485, Johannesburg, South Africa.

THURSTON, EDWARD D., JR., A.B., M.E. 1907
113 East 29th St., N. Y. City.

THURSTON, L. S., E.E. 1902
44 Broad St., N. Y. City.

THYNG, WILLIAM S., E.M. 1896
Gen. Mgr. Roselle Mining Co., Spokane, Wash.

TIBBALS, GEORGE ATWATER, C.E. 1883
The Continental Iron Works, Brooklyn, N. Y. City.

TIBBALS, R. G., C.E. 1897
Continental Iron Works, 148 Milton St., Brooklyn, N. Y. City.

TIBBALS, SAMUEL GAYLORD, C.E. 1884
The Continental Iron Works, Brooklyn, N. Y. City.

TIEMANN, HUGH PHILIP, B.S. (CHEM.), A.M. (METALLURGY) . . 1900
Sales Dept., Carnegie Steel Co., Pittsburgh, Pa.

TILDEN, G. C., C.E. 1876
Golden, Col.

TILGHMAN, H. A., E.M. 1893
Sansleto, Cal.

TILLSON, BENJAMIN F., PH.B., E.M. 1907
Care D. A. Rexford, No. 80 Broadway, N. Y. City.

TILT, BENJAMIN BRICKLYN, E.E. 1900
106 Spring St., N. Y. City.

TITCOMB, HAROLD ABBOT, A.M., E.M. 1898
John Hays Hammond & Guggenheim Exploration Co., 71 Broadway, N. Y. City.

TITUS, SAMUEL HOWARD, E.E. 1901
354 Grand Ave., Brooklyn, N. Y. City.

TITUS, WARREN HARRIOT, E.M. 1885
111 Blackstone Boulevard, Providence, R. I.

TOCH, MAX B., PH.B. (ARCH.) 1896
34 West 92d St., N. Y. City.

TOLL, ROGER W., C.E. 1906
1654 Massachusetts Ave., Cambridge, Mass.

TOMBO, CARL, B.S., C.E. 1902
Box 30, Sta. J, N. Y. City.

TOMPKINS, E. D. V., C.E. 1896
1 Madison Ave., N. Y. City.

TOMPKINS, J. A., 2D, PH.B. 1894
Astor Court, 25 West 33d St., N. Y. City.

TONNELE, THEODORE, PH.B. (CHEM.) 1880
William Dewees Wood Co., McKeesport, Allegheny Co., Pa.

TOTTEN, GEORGE OAKLEY, JR., PH.B. (ARCH.) 1891
801 Nineteenth St., N. W., Washington, D. C.

TOUCEY, DONALD BUTLER, LL.B., E.M. 1882
275 Broadway, N. Y. City.

Towart, James, C.E. 1892
Box 296, Peekskill, N. Y.

Tower, A. E., E.M. 1883
Poughkeepsie, N. Y.

Tower, Frederick W., E.M. 1887
1241 Irving St., Washington, D. C.

Tracy, William E., A.B. (Yale, 1900), E.M. 1904
Supt. of Liberty Bell G. M. Co., Telluride, Col.

Traphagen, Frank Weiss, Ph.B. (Chem.), Ph.D. 1882
Prof. of Metallurgy and Assaying, Colorado School of Mines, Golden, Col.

Trapote, P., C.E. 1898
335 West 58th St., N. Y. City.

Trask, George F. D., E.M. 1887
20 Warren St., N. Y. City.

Trippe, William H., E.E. 1905
Eng. Apprentice at Westinghouse Elect. and Mfg. Co., East Pittsburgh, Pa.

Trowbridge, Samuel Breck Parkman, A.B., Ph.B. (Arch.) 1886
287 Fourth Ave., N. Y. City.

Truax, Sewall, E.M. 1903
Gen. Mgr. Granadena Min. Co., Santa Barbara, Chihuahua, Mexico.

Tubby, J. T., Jr., Ph.B. (Arch.) 1896
67 Willow St., Brooklyn, N. Y. City.

Tucker, Allen, Ph.B. 1888
19 Liberty St., N. Y. City.

Tucker, S. A., Ph.B. (Chem.) 1895
Columbia University.

Tudor, William, Jr., E.M. 1898
Supt. Santa Fé Gold and Copper Mining Co., New Mexico.

Tulloch, Thomas H., E.M. 1907
Mina Las Chispas, Arizpe, Sonora, Mexico, via Naco, Ariz.

Tuska, Gustav R., B.S., M.S., C.E. 1891
Consulting Engineer, 62 William St., N. Y. City.

Tuttle, Edgar Granger, E.M. 1881
Consulting Mining Engineer, Breckenridge, Col.

Tuttle, William W., E.M. 1867
713 East Elm St., Springfield, Mo.

Tweedy, Andrew M., E.M. 1906
Montezuma Lead Co., Sta. Barbara, Chihuahua, Mexico.

Tyler, William R., C.E. 1904
Surveyor and Concrete Inspector for Astoria Light, Heat and Power Co., 36 West 93d St., N. Y. City.

Uhlig, William C., Ph.B. (Chem.) 1896
242 Halsted St., East Orange, N. J.

Ungrich, Martin J., E.M. 1902
Draftsman, Dept. Docks and Ferries, 393 Lenox Ave., N. Y. City.

Updike, David M., E.M. 1907
Care A. D. Granger & Co., 90 West St., N. Y. City.

Vail, Lewis H., E.E. 1894
Asst. Elect. Engr., D., L. & W. R. R., Scranton, Pa.

Value, B. R., E.M. 1884
Niagara Falls, Canada.

Van Arsdale, William Henry, A.B., A.M., E.M. 1868
Vice-Pres. Chicago and Aurora Smelt. and Ref. Co., Aurora, Ill.

Van Benthuysen, Boyd, Ph.B. (Arch.) 1896
Care Morgan, Harjes & Co., Paris, France.

Van Blarcom, E. C., C.E. 1876
Hidalgo, Mexico.

Van Boskerck, Robert Ward, E.M. 1877
58 West 57th St., N. Y. City.

Van Brunt, Arthur Hoffman, Ph.B. (Arch.) 1886
54 Wall St., N. Y. City.

Van Cise, W. M., Mech.E. 1903
Summit, N. J.

Van Cortlandt, Edward Newenham, E.M. 1885
Consulting Engineer, 305 Cooper Bldg., Denver, Col.

VANDERBILT, WILLIAM D., C.E. 1894
39 Monroe Place, Brooklyn, N. Y. City.

VAN DEVENTER, CHRISTOPHER, E.E. 1897
Stanley Electric Mfg. Co., Monadnock Building, Chicago, Ill.

VANDERPOEL, FRANK, E.M., PH.D. 1875
Consulting Chemist, 153 Centre St., Orange, N. J.

VAN DYCK, EDWIN, PH.B. (CHEM.) 1888
Washington, D. C.

VAN DYCK, WILLIAM VAN B., M.S., E.E. 1897
84 College Ave., New Brunswick, N. J.

VAN GELDER, A. P., PH.B. (CHEM.) 1896
Box 406, Emporium, Pa.

VAN HORNE, JOHN REGINALD, MECH.E. 1901
4404 West Pine Boulevard, St. Louis, Mo.

VAN INGEN, DUDLEY ARTHUR, PH.B. (CHEM.) 1892
Care N. J. Zinc Co., Newark, N. J.

VAN LENNEP, DAVID, E.M. 1867
Auburn, Placer Co., Cal.

VAN SICLEN, MATTHEW, A.B., E.M. 1906
Piedias Verdas Mine, Urique, Chihuahua, Mexico.

VAN SINDEREN, HOWARD, PH.B. (CHEM.), LL.B. 1881
Attorney and Counsellor-at-Law, 35 Wall St., N. Y. City.

VAN VALKENBURGH, EDWARD, JR., C.E. 1888
41 Wall St., N. Y. City.

VAN VLECH, JOSEPH, JR., PH.B. (ARCH.) 1896
327 Claremont Ave., Montclair, N. J.

VAN VOORHIS, B. W., 2D, E.E. 1898
Apartado 216, Monterey, Mexico.

VAN WAGENEN, H., JR., B.S. (ARCH.) 1899
36 East 53d St., N. Y. City.

VAN WAGENEN, T. F., E.M. 1870
P. O. Box 1346, Denver, Col.

VATABLE, J. J., PH.B. (ARCH.) 1894
111 Fifth Ave., N. Y. City.

VER PLANCK, WILLIAM EVERETT, E.E. 1902
Asst. Engr., Gen. Electric Co., Lynn, Mass.

VOLCKENING, G. J., MET.E., E.M. 1888
778 Greene Ave., Brooklyn, N. Y. City.

VOM BAUER, C. H., E.E. 1899
681 Seventy-ninth St., Brooklyn, N. Y. City.

VONDY, RUDOLPH HARRISON, E.M. 1882
21 East 39th St., Bayonne, N. J.

VON FINTEL, ERNEST A., C.E. 1895
Asst. Engineer, Blackwell's Island Bridge.

VON NARDROFF, ERNEST ROBERT, E.M. 1886
Head of Science Dept., Erasmus Hall High School, Brooklyn, N. Y. City.

VON SHOLLY, BENJAMIN R., M.A. 1905
Gas Engr. to Power and Mining Machine Co., Milwaukee, Wis.

VON SCHRENK, ARNOLD, E.E. 1901
With Gen. Elec. Co., Steam Turbine Construction Dept., N. Y. City.

VREDENBURGH, WATSON, JR., C.E. 1898
Consulting Engineer, 50 Broadway, N. Y. City.

VULTE, HERMAN T., PH.B. (CHEM.), PH.D. 1881
Adjunct Professor in Domestic Science, Teachers' College, Columbia Univ.

WAGNALL, OTTO, E.M. 1898
63 East 72d St., N. Y. City.

WAINWRIGHT, JOHN HOWARD, PH.B. (CHEM.) 1882
Chemical and Mining Engineer, 60 Wall St., N. Y. City.

WAINWRIGHT, RICHARD TIGHE, C.E. 1890
Rye, N. Y.

WALDENBERGER, C. A., PH.B. (CHEM.) 1897
P. O. Box 69, Jersey City, N. J.

WALDRON, J. LAWRENCE, A.B., M.E. 1907
With Babcock & Wilcox Boiler Co., 85 Liberty St., N. Y. City.

Walker, Arthur Lucien, E.M. 1883
Director A. S. & R. Co., 71 Broadway, N. Y. City.

Walker, Fred. W., C.E. 1895
21 Van Reipen Ave., Jersey City, N. J.

Walker, Henry Vincent, Ph.B. (Chem.) 1894
Inspector, Dept. of Health, Brooklyn, N. Y.

Walker, Joseph, Jr., C.E. 1880
112 East 37th St., N. Y. City.

Wallace, William J., Ph.B. (Arch.) 1886
1 Union Square, N. Y. City.

Wallace, William Murray, E.E. 1902
60 East 92d St., N. Y. City.

Wallbridge, Frederick Kidder, E.M. 1884
Builder, 147 Lafayette Ave., Brooklyn, N. Y. City.

Waller, Elwyn, A.B., A.M., E.M., Ph.D. 1870
Consulting Chemist, 159 Front St., N. Y. City.

Wallower, Frank C., E.M. 1906
Keystone Hotel, Joplin, Mo.

Walsh, F. P., Mech.E. 1903
With Sargent & Lundy, Chicago, Ill.

Walsh, Louis Angelo, B.S. (Arch.) 1900
Waterbury, Conn.

Walter, John C., E.E. 1904
With Ford, Bacon & Davis, 172 Walnut St., Memphis, Tenn.

Walz, Andrew, E.M. 1905
50 West 110th St., N. Y. City.

Wampold, Leo, Ph.B. (Chem.) 1888
Insurance Adjuster, 627 N. Y. Life Building, Chicago, Ill.

Wanier, Albert George, Ph.D. 1882
31 Nassau St., N. Y. City.

Ward, Delancy Walton, Ph.B. (Chem.) 1888
Instructor in Chemistry, N. Y. College of Dentistry.

Ward, Frederick E., E.E. 1905
With Crocker-Wheeler Co., Ampere, N. J.

Ward, Robert Reillieux, E.M. 1882
412 McDonough St., Brooklyn, N. Y.

Ware, Arthur, B.S. (Arch.) 1898
1285 Madison Ave., N. Y. City.

Ware, F. B., Ph.B. (Arch.) 1894
1285 Madison Ave., N. Y. City.

Warner, J. L., E.M. 1887
Care Bradley Engineering Co., Spokane, Washington.

Warren, Charles P., Ph.B. (Arch.), A.M. 1890
Astor Court Building, N. Y. City.

Warren, Lloyd, Ph.B. (Arch.) 1891
520 Fifth Ave., N. Y. City.

Warren, W. A., (Associate) . . . .

Warren, William Tilman, B.S. (Arch.) 1902
Bronxville, N. Y.

Warth, Albin H., B.S. (Chem.) 1907
19 Smith Terrace, Stapleton, N. Y.

Waterbury, Cornelius Reed, C.L., C.E., LL.B. 1877
20 Broad St., N. Y. City.

Waterhouse, George Booker, Assoc. in Metallurgy (Univ. Coll., Sheffield, Eng.), Ph.D., Coll. Univ., 1906 1907
Care Lackawanna Steel Co., Buffalo, N. Y.

Waters, George Safford, Ph.B. (Arch.) 1889
42 West 43d St., N. Y. City.

Waters, Rossiter Lester, Mech.E. 1902
80 West 94th St., N. Y. City.

Watkins, Samuel S., E.E. 1906
223 West 106th St., N. Y. City.

Watson, Charles Edward, E.M. 1902
Mining Engineer, Germiston, Transvaal, South Africa.

Watson, Frank Whalley, E.M. 1904
Vice-Pres. Pacific Coast Construction Co., Portland, Oregon.
Watson, Rolla Barnum, E.M. 1891
Consulting Engineer, Shannon Copper Co., Clifton, Arizona.
Watson, William, E.M. 1898
25 Broad St., N. Y. City.
Wedekind, E. H., Ph.B. (Geol.) 1889
Goldfields, Nevada.
Weed, Walter Harvey, E.M. 1883
Mining Geologist, 100 East Ave., Norwalk, Conn.
Weeks, R. D., B.S. (Arch.) 1898
Ridgewood, N. J.
Weeks, William Holden, Ph.B. (Chem.) 1889
Lawyer, 789 Madison Ave., N. Y. City.
Weichsel, Oscar M., E.M. 1904
Engineer, Blue Ledge Mine, Medford, Oregon.
Weil, Arthur B., E.E. 1902
1254 East Madison Ave., Cleveland, Ohio.
Weinrich, Morris F., Mech.E. 1904
Asst. in Drawing, Columbia University, N. Y. City.
Weinstein, M., C.E. 1899
544 West 142d St., N. Y. City.
Welch, Alex. McMillan, Ph.B. (Arch.) 1890
11 East 42d St., N. Y. City.
Welcke, Celestin John, E.E. 1902
237 West 112th St., N. Y. City.
Wells, D. C., E.E., A.B. 1896
New Milford, Conn.
Wells, J. S. C., Ph.D. 1875
Adj. Professor in Anal. Chem., Columbia University.
Wels, Paul O., E.M., B.S. 1887
Caldera, Chili.
Welsh, Howard Farrington, E.M. 1890
Billings, Mont.
Wemlinger, Julius Ralph, C.E. 1900
Pres't Wemlinger Steel Piling Co., 11 Broadway, N. Y. City.
Werner, Gerard B., A.B., E.E. 1905
319 West 94th St., N. Y. City.
Werner, Henry Clay, Ph.B. (Arch.) 1892
120 East 65th St., N. Y. City.
Wertheimer, Lewis, Ph.B. 1887
Allegheny City, Pa.
Wessels, Eugene Herbert, E.E. 1900
29 West 91st St., N. Y. City.
Westbrook, Francis A., Mech.E. 1906
With N. Y. Telephone Co., 37 Strong Place, Brooklyn, N. Y. City.
Westervelt, William Young, E.M. 1894
Consulting Mining Engineer, 100 William St., N. Y. City.
Wetmore, Edwin Atwater, E.M. 1875
Box 131, Marysville, Mont.
Wheatley, Joseph Y., C.E. 1886
Cold Spring, N. Y.
Wheeler, Bleecker L., E.M. 1905
Rhyolite, Nevada.
Wheeler, Herbert Allen, E.M. 1880
Mgr. Penicant Lead Co., 510 Pine St., St. Louis, Mo.
White, Francis Joseph, E.E. 1902
Battery Engr., N. Y. C. & H. R. R. R., 53 St. John's Pl., Brooklyn, N. Y. City.
White, Lazarus, C.E. 1897
18 West 119th St., N. Y. City.
White, R. D., C.E. 1892
20 Broad St., N. Y. City.
White, William S., E.M. 1882
Manufacturer Building Papers, Lydecker St., Englewood, N. J.
Whiting, Lowe, E.M. 1895

WHITLOCK, HERBERT PERCY, C.E. 1889
Mineralogist, N. Y. State Museum, Albany, N. Y.

WHITMAN, EDWARD PINEO, E.M. 1885

WHYTE, WILLIAM DE BURGH, E.M. 1902
Columbia University Club, N. Y. City.

WICKES, LEWIS WEBSTER, MET.E. 1903
Supt. Ely Witch Copper Co., Ely, Nevada.

WIECHERS, JOHN H., E.E. 1906
P. O. Box 643, Mexico City, Mexico.

WIECHMANN, FERDINAND G., PH.B. (CHEM.), PH.D., F.C.S. . . . 1881
Consulting Chemical Engineer, 814 West End Ave., N. Y. City.

WIENER, WILLIAM, A.M., PH.B. (CHEM.) 1891
Prof. of Chemistry and Physics, Newark High School, Newark, N. J.

WIGGIN, JOHN D., B.S. (CHEM.) 1906
23 Snyder St., Orange, N. J.

WILCOX, SIDNEY H., E.M. 1906
San José, Costa Rica, Central America.

WILL. P., MECH.E., E.M. 1904
Supt. Sill Stove Works, Rochester, N. Y.

WILLARD, PAUL DAY, E.M. 1907
Hibbing, Minn.

WILLETS, R. H., E.M. 1905
Roslyn, N. Y.

WILLHOFFT, FREDERICK O., MECH.E. 1904
Prof. of Mech. Eng., Queen's University, Kingston, Canada.

WILLIAMS, FREDERICK HARRISON, E.M. 1874
National Tube Co., Wheeling, W. Va.

WILLIAMS, G. W., E.M., C.E. 1879
Pres't Murray Hill Iron Works, 212 East 37th St., N. Y. City.

WILLIAMS, JOHN TOWNSEND, E.M., PH.B. 1873
Constructing Engineer, Mine Owner and Operator, 27 William St., N. Y. City.

WILLIAMS, JOHN TOWNSEND, JR., PH.B. (ARCH.) 1900
27 William St., N. Y. City.

WILLIAMS, ROBERT Y., A.B., E.M. 1904
Gen. Supt. Clearfield and Ohio River Coal Co., Moundsville, W. Va.

WILLIAMS, R. T., MET.E. 1905
244 Purdy St., Long Island City, N. Y.

WILLIAMS, WILLIAM F., C.E., E.M. 1881
City Engineer, New Bedford, Mass.

WILLIAMSON, ALFRED, MECH.E. 1902
Mech. Engr., Dept. Gas, Water Supply and Electricity, N. Y. City.

WILLIAMSON, GEORGE N., JR., B.S. (CHEM.) 1903
Supt. for Williamson & Co., 321 West 106th St., N. Y. City.

WILLIS, BAILEY, E.M., C.E. 1878
Geologist, U. S. Geological Survey, Washington, D. C.

WILLIS, HARRY THOMAS, B.S., E.M. 1904
Champaign, Ill.

WILLIS, RUSSELL H., E.M. 1906
104 West 39th St., N. Y. City.

WILMOT, H. CLIFFORD, E.M. 1902
Supt. Development Co., Butte, Mont.

WILNER, ELIAS RALPH, MECH.E. 1902
Gen. Mgr. Manhattan Screw and Stamping Co., 133 West 12th St., N. Y. City.

WILSON, CHARLES HENRY, E.M. 1902
Wilson-Maeulen Co., Pyrometers, Mt. Vernon, N. Y.

WILSON, CLARENCE EDGAR, PH.B. (ARCH.) 1886
Yonkers, N. Y.

WILSON, FRED. FIELDING, B.S. (ARCH.) 1902
Helena, Mont.

WILSON, HERBERT M., C.E. 1881
Geographer, U. S. Geological Survey, Washington, D. C.

WILSON, L. G., MECH.E. 1901
Asst. Mgr., J. G. Wilson Mfg. Co., Norfolk, Va.

WILSON, WILLIAM ALEXANDER, E.M. 1882
Consulting Engineer, Salt Lake City, Utah.

WILTSEE, ERNEST ABRAM, E.M. 1885
Consulting Engineer, 111 Broadway, N. Y. City.

WINDECKER, CLIFTON NICHOLAS, C.E. 1892
Barberton, Ohio.

WINDOLPH, A. P., PH.B. 1892
331 West 31st St., N. Y. City.

WINETRAUB, A. I. M., E.E. 1905
Chief of Eng. Dept. of Sussdorf, Zaldo & Co., N. Y. City.

WITHERELL, CHARLES S., MET.E. 1896
Supt. Copper Plant of A. S. & R. Co., Perth Amboy, N. J.

WITTIG, GUSTAV F., E.E. 1904
University of Maine, Maine.

WITTMACK, CHARLES AUGUSTUS, M.S., PH.B. (CHEM.), PH.D. . . 1882
Consulting Chemist, 606 West 113th St., N. Y. City.

WITTMANN, RUDOLPH W., MECH.E. 1902
Supt. for Wittmann Bros., N. Y. City.

WOLFF, ARTHUR MOSES, C.E. 1903
31 West 54th St., N. Y. City.

WOLFF, H. H., C.E. 1898
470 Greenwich St., N. Y. City.

WOLFF, JOHN BENJAMIN, C.E. 1901
31 West 54th St., N. Y. City.

WOLFF, W. A., E.E. 1905
With Western Electric Co., N. Y. City.

WOOD, DENNISTOUN, JR., MECH.E. (CHEM.) 1902
With Southern Pacific Co., San Mateo, Cal.

WOOD, GEORGE E., E.M., PH.B. 1884
63 William St., N. Y. City.

WOODRUFF, GEORGE W. L., PH.B., E.E. 1896
2345 Broadway, N. Y. City.

WOODS, WILLIAM A. E., E.M. 1905
576 Alvarado St., San Francisco, Cal.

WOODWARD, ROBERT SIMPSON, JR., C.E. 1901
Consulting Engineer, 2 Wall St., N. Y. City.

WOOLSON, IRA HARVEY, E.M. 1885
Adj. Professor of Civil Engineering, Columbia University.

WORMSER, MORITZ, A.B., C.E. 1903
Lakeville, Conn.

WRIGHT, R. G., B.S. (CHEM.) 1899
Chemist, Washington, D. C.

WYCKOFF, CHARLES R., JR., B.S., C.E., A.M. 1902
Asst. Engr., Board of Water Supply, N. Y. City.

WYLD, ROBERT H., MECH.E. 1904
With Power Specialty Co., 1012 Chemical Building, St. Louis, Mo.

YATES, WILLIAM H., C.E. 1903
449 West 123d St., N. Y. City.

YOUNG, A. BURGESS, E.M. 1906
With Canadian Copper Co., Copper Cliff, Ontario, Canada.

YOUNG, EDWARD LEAVITT, E.M. 1882
Takata & Co., N. Y. City.

YOUTZ, L. A., PH.D. (CHEM.) 1902
Professor of Chemistry, Lawrence University, Appleton, Wis.

YRIZAR, ROBERTO, A.B., E.M. 1895
Gen. Mgr., Sta. Ana Mine, Catorce, Mexico.

YUNG, MORRISON BROWN, PH.B., E.M. 1901
Hartford, Conn.

ZIPSER, MORRIS E., C.E. 1901
With Board of Water Supply, N. Y. City.

ZUCKER, ARTHUR A., E.E. 1902
27 William St., N. Y. City.

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